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JANUARY—DECEMBER, 1877.

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THE
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No. I.—JANUARY, 1877.

ORIGINAL ARTICLES.

I.—On Evolution in Geology.

By W. J. Sollas, B.A., F.G.S.,
Lecturer on Geology, Cambridge University Extension.

THAT the energy of the earth and the sun is a continually diminishing quantity, and must at the beginning of geologic history have been far in excess of its present amount, are propositions that few at the present day would be found to deny; but the exact influence of this greater quantity of energy on geologic changes has not, I believe, been hitherto fully discussed.[1]

The Sun.—The Sun is a large and exceedingly hot star, cooling slowly in space, and it is because it is so large and hot that it has been able to supply our world and all the other members of its system with so much heat for so long a time. It is daily losing heat, and it is the heat thus lost by the sun, and gained in part by us, that supplies the energy requisite for the work of most denuding agents.

If the sun then be a cooling body, its store of energy must have been greater yesterday than it is to-day, by exactly the equivalent of the amount of heat it has radiated since then; and so of all previous yesterdays: so that if we go back far enough in time, we shall reach a period when the store of energy in the sun was too great to permit of its existence in its present state. This period, as calculated by Sir William Thomson, is placed as far back as from 100 to 500 millions of years ago.[2] But it is a law of cooling bodies that they cool the quicker the higher their temperature is above that of the surrounding medium. The space in which all worlds exist, the medium which surrounds our sun, appears to have no sensible temperature of its own, or what temperature it has is generally taken as practically constant.

---

[1] The views contained in this paper, the sources of some of which will be obvious, were first expressed before the Halifax Philosophical Society, in a lecture which I delivered in 1874, and afterwards in a paper read before the Leeds Geologists' Association. They are now printed in a condensed form and rather as suggestions than anything else.

[2] The increased amount of energy in the sun does not imply a corresponding elevation of temperature; to a great extent such additional energy was potential, but from all we know it seems most probable that an increase in potential would be accompanied in this case by an increase in kinetic energy, and so we may safely assume that the temperature of the sun rises in an ascending curve as we proceed backwards in time. The more rapid conversion of potential into kinetic energy, which probably occurred at intervals, would produce fluctuations in temperature, and so the temperature curve in the sun's history is probably not a simple line, but varied *by numerous minor undulations.*

Thus by raising the temperature of our luminary we increase the difference between its temperature and that of surrounding space. It will consequently cool quicker than when its temperature is lower and the difference in temperature correspondingly less.

In radiating its heat away more rapidly, it will supply our earth with a greater quantity of energy, which only comes to saying what is obvious enough, that when the sun was hotter, it shone with increased intensity on the earth.

The Earth.—The same conclusion may be held to be true as regards the earth, likewise considered as a body cooling in space. It is now very hot inside, but at one time it must have been much hotter; every century that has passed over it, has left it more and more impoverished in heat. It becomes hotter not only as we descend its crust, but also as we pass backwards in time.

The rate at which it cools can only be determined by making use of data confessedly imperfect, and from these Sir Wm. Thomson finds that 100 or 200 millions of years ago it first began to be crusted over by a solid film of rocks; that 10,000 years after its first crusting over the temperature of the crust increased 2° F. for every 1ft. vertically descended below the zone of constant temperature. The rate of increase for descent with successive periods is shown in the following table:

Period after crusting over. YEARS.	Rate of increase in temperature for every 1ft. descended.
10,000	2° F.
40,000	1°
160,000	$\frac{1}{2}$°
4,000,000	$\frac{1}{10}$°
100,000,000	$\frac{1}{51}$°

$\frac{1}{51}$ of a degree being the present rate of increase.

Various estimates have been made by geologists of the time which has elapsed since the deposition of the earliest recorded strata, from the time the Laurentian were first laid down to the present day. From 500 to 50 millions of years would, I think, include the least extravagant of them, a period which brings the period of formation of the earliest known strata into very close proximity with that when the sun first began his existence as our luminary, and when our earth was first permanently crusted over.

Prof. Thomson's estimates may be wrong, and the estimates of the geologists may be wrong, either or both may be erroneous to a considerable degree; but even if we put Sir Wm. Thomson's periods farther back, twice as far back, or bring the Laurentian period nearer to us, there will yet remain a very considerable excess of energy, both in the sun and in our planet, beyond what they at present possess, and the influence of which must have been distinctly sensible on the rate of early geologic change. It is therefore not only legitimate, but it even becomes necessary, to consider what must have been the precise effects of this excess of energy on the earlier physical geography of our globe.

Velocity of the Earth's Rotation.—The retardation of the earth's rotation, owing to the drain upon its energy in supplying the work done by the tides, has not yet, perhaps, been accurately estimated as to its amount, but as to its existence there can be little or no doubt. From this it follows that the rate of rotation of the earth was greater in the earlier stages of its history, and has continually decreased from then to the present day.

Chemical Energy.—The chemical energy which chiefly concerns us here is the unsatisfied affinity of carbonic anhydride. All sedimentary rocks must ultimately be traced to an igneous source, and those strata which are composed of carbonates must, in the long run, have resulted from the combination of the original carbonic anhydride of the atmosphere with the constituent of some igneous rock.

Confining our attention to carbonate of lime, it is clear that every bed of this material bears testimony to so much carbonic anhydride extracted from the atmosphere, and, by calculating the quantity of carbonic anhydride which any given limestone bed contains, we determine by how much the atmosphere of our planet has been deprived by it of that constituent. Thus one cubic mile of limestone contains about four thousand million tons of carbonic anhydride, *i.e.* about $\frac{1}{50000}$ part of the whole amount of this gas at present existing in the atmosphere. The Laurentian formation of Canada alone covers an area of 200,000 square miles of the earth's surface, and contains limestone beds amounting altogether to 4000 ft. in thickness. Proceeding on the assumption that this is the average thickness, which of course it is not, it is easy to determine that the quantity of carbonic anhydride stored away in these Laurentian limestones alone exceeds by four times the quantity of carbonic anhydride at present existing in the atmosphere; or, in other words, that if it could be again restored to the air, it would increase the existing per-centage therein from ·04 to ·2 per cent.; and when we consider all the calcareous rocks of the Silurian, Carboniferous, Triassic, Jurassic, Cretaceous, and Eocene formations now exposed at the earth's surface, and the unknown beds of limestone, probably surpassing all these in thickness and extent, now buried beneath the sea, then we have abundant testimony to the extraordinary richness of this carbonic anhydride gas in the original atmosphere of the earth, before it had been extracted, by virtue of its affinity for the lime of calcic silicates, and imprisoned in the solid form in limestone strata. And the same evidence moreover shows that it has been continually diminishing in amount from the earliest to the most recent geologic times.

Influence of increased Solar and Terrestrial energy on the rate of Geologic Change.

1. *Disintegration by carbonic anhydride.*—One does not know what proportion of the carbonic anhydride which is effective in the disintegration of rocks is directly dissolved by rain-water from the

atmosphere, and what proportion is furnished by that constant carbonic anhydride generator—decaying vegetable matter.

That directly dissolved would increase with the increased amount of carbonic anhydride present in the air, but it would on the other hand be diminished by the higher temperature which, as we shall show, the earlier rain-water possessed; and as the subterranean waters were also in the earlier periods warmer than they now are, the quantity of carbonic anhydride absorbed by them would also be for this reason less. It is thus impossible to say whether the presence of an excess of carbonic anhydride in the air would do more than very partially compensate for its diminished solubility in water warmer than the present.

2. *Denudation by rain and rivers.*—As the rate of this depends *ceteris paribus* on the amount of rainfall, we have now to inquire how far this quantity would differ in the earlier from that of the later geologic times.

The rainfall is the result of the difference in temperature met with in passing from the equator to the poles and from the surface of the earth to the higher regions of the atmosphere.

Owing to increased radiation from the sun, our earth must have possessed a higher temperature all over its surface in the earlier geologic periods, and in addition to this a more extreme difference in temperature must have existed between the poles and the equator. The *ratio* of this difference would of course remain the same, since that depends on an unvarying cause, but the *actual* difference would be much greater, as also would be the difference between the temperature at the surface of the earth and in the higher regions of the atmosphere. The general elevation of a constant temperature-difference to a higher temperature level would of itself be sufficient to cause increased evaporation and greater rainfall. As an illustration of this let us mix together 1 cubic inch of air saturated with aqueous vapour at 100°C. with another cubic inch saturated at 60°C., a difference of temperature of 40° C. The result will be that 4·1 grains of water will be precipitated. Now let us take 1 cubic inch saturated at 65·5° C. and mingle it with 1 cubic inch at 15·5° C., a temperature-difference greater than in the first case, viz. 50° C. The condensed aqueous vapour will now weigh only 1 grain; one quarter the quantity of the former instance.

Thus a merely equable elevation of the earth's temperature would suffice of itself to produce greatly increased rainfalls,—greater not simply in proportion to the elevation to a higher temperature level of the temperature-difference on which they depend, but in an increasing ratio; and when to this we add the effects of an actual increase in the temperature-difference itself, we shall obtain a rainfall which will very forcibly indicate that the increased radiation from the sun must have had its full influence in producing a more copious evaporation of terrestrial waters, and a corresponding condensation of aqueous vapour.

Here we may notice in passing, that the rain would be warmer *than the present,* and it would fall upon a warmer terrestrial surface; the difference in temperature might not be very great, but it would exist. From the increased rainfall would necessarily follow a more rapid corrosion of the general surface of the land, and a speedier degradation of its general level. The sculpturing of hills and valleys and the delivery of detritus to the sea must have proceeded at a swifter rate; and indeed all the activities of rain and rivers would be stimulated to relatively greater energy.

3. *Subterranean Waters.*—Not only would the amount of these be augmented by the increased rainfall, but they would be influenced by the higher temperature of the earth's crust; thus in the present period percolating water must descend on the average 51 feet below the zone of constant temperature in order to rise 1° in temperature; 4,000 years after the permanent incrustation of the earth, the same descent would be accompanied by an elevation of 5° in temperature.

4. *Marine Denudation. The Waves.*—The difference of temperature which produces the rainfall also drives the winds in their courses, just as truly as the difference in temperature between the boiler of a steam engine and the external air drives the piston. Augment the difference and the winds will flow faster and more violently, just as certainly as fresh fuel will urge the engine with greater activity. Thus the denudation accomplished by the winds will also be accelerated, especially that disintegration of sea-cliffs which they produce indirectly. For it is the winds ruffling the ocean which produce the sea-waves, and it is the energy of these directed to the battering down of the cliffs along every coast-line which produces a great part of the work of marine denudation.

Tides.—These are due to the rotation of the earth between the attracting bodies of the sun and moon, and since this rotation must have been more rapid the further back we recede in time, so must it have conferred greater energy on the actions of the tides. Let the velocity of the earth's rotation be doubled, and the tides will rise four times instead of twice in every twenty-four hours, and with greater frequency will attain also greater velocity. But it is the tides and tidal currents which are, amongst others, the most persistent agents in coast-line transportation; and thus the detritus produced with increased rapidity by the disintegrating actions of the rain and waves, will be with corresponding rapidity carried away to preserve the coast-line constantly exposed to renewed decay.

Marine Currents.—All these, excepting those produced by the tides, are ultimately due to differences in temperature on which the winds also depend, and thus will likewise flow with accelerated velocity, and consequently their influence as transporting agents will be correspondingly exalted.

Deposition.—The rate of deposition is always directly proportional to the rate of denudation, and may be said at any particular time to equal it. Thus any increase in the rate of denudation will be necessarily accompanied by a corresponding increase in the deposition of sediment. If we look for any direct proof of this, there is but little to be found. *Prof. Phillips has* shown that the proportion *of the number of fossil species to* the thickness of its strata constantly diminishes as we proceed from the more recent to the older rocks: and certainly the length of time required for the formation of the Palæozoic rocks, calculated according to their thickness and the rate of existing processes of deposition, would be far in excess of that derived from a consideration of the changes in their fossil fauna. That this might indicate a quicker rate of deposition I pointed out in my lectures two years ago. while a previous writer has endeavoured to prove the converse proposition, viz. that the changed proportion indicates that the rate of variation amongst animals and plants must have progressively increased from the earliest to the latest times. Certainly the continual increase of the sum total of species, an increase only partially checked by the extinction of some species, will give greater opportunities for variation; but beyond this there appears but little to explain a progressively increasing rate of variation which should affect all the great classes of animals alike; and since the organic world seems to change much less quickly than the mineral one, one feels much more inclined to attribute the greater thickness of the older rocks, in proportion to the number of their contained species, to an accelerated rate of deposition. than the contrary. If this be the correct view, and the change in proportion be available as a means of measurement, we shall then find that the Palæozoic rocks were deposited three times as rapidly as the Cainozoic strata, since they contain one quarter the number of species of fossils for the same given thickness of rocks.[1]

Metamorphosis.—This results from the descent of sediments towards the interior of the earth, by which they become exposed to a temperature high enough, under the circumstances, to alter their character. The readier metamorphosis of the earlier rocks follows naturally from the more rapid rise of temperature which then occurred for a given descent into the earth's crust from its surface, and from the greater activity of crust-movements, which we shall show characterized the earlier epochs.

Using Sir William Thomson's estimates for an illustration of the former influences, we find that 4,000,000 years after permanently incrusting, the temperature-increase for every foot descended into the crust is $\frac{1}{10}$: and thus a descent of rocks 100,000 ft. from the surface—by no means an improbable amount—would bring them into regions the temperature of which would at least amount to 10,000° F., by which of course they would necessarily be fused and re-absorbed into the melted interior of the earth.

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[1] The studious reader who desires to enter more fully into this question of the "Rate of Geological Change" should consult Prof. Huxley's Presidential Address to the Geological Society (1869), Quart. Journ. Geol. Soc., vol. xxv.: Prof. E. Forbes "On the Manifestation of Polarity in the Distribution of Organized Being in Time" (Royal Inst. Lectures, vol. i. p. 428): Prof. Phillips' Rede Lecture Cambridge, 1860, afterwards published by Macmillan under the title "Life on the Earth," 1860; and an able article by Mr. H. M. Jenkins, F.G.S., Sec. Royal Agl Soc. of England, "On the Rate of Geological Change," Quart. Journ. Science 1870, vol. vii. p. 322.—EDIT. GEOL. MAG.

The Laurentian strata were clearly never exposed to a temperature like this, but it is quite conceivable that their wide-spread and extreme state of metamorphosis may be connected with the early date of their origin.

Elevation and Depression of Strata.—The movements of the earth's crust are generally allowed to be due to the loss of heat from within it, whether by the wrinkling or the crushing of the crust on a contracting nucleus, or by any other means. But at the beginning of geologic time the temperature was much more elevated above that of its surrounding medium than at present, and consequently cooling or the loss of heat must have gone on more rapidly than at present, and from this follows a more rapid progress of those movements of upheaval and subsidence depending on this cooling. Thus elevation and depression of strata must have occurred with greater rapidity in the earlier than in the later stages of our planet's history.

Summary.—We have now shown that the decreasing energy of the sun and of the earth must have led to diminishing rapidity in the action of three of the main factors of geologic change, viz. on the *denudation*, *reproduction*, and the *elevation* and *depression* of strata.

In spite of all fluctuation resulting from more than usually rapid conversions of potential into kinetic energy, the loss of energy continually proceeds, and as continually is accompanied by a decrease in the rate of geologic change, just as certainly as the greater periodical activity in the solar radiation once every 11·2 years gives rise to exactly opposite results.

If then denudation and deposition take place with accelerated velocity as we recede from the present time, how great is the mistake of attempting to check the results as to the age of the world obtained by the physicist with those deduced by the geologist, as though the methods of both were independent of each other, while all the time the latter proceeds upon the assumption that the rate of geologic change has on the whole been always constant, and the former disproves this in a corrollary to his chief argument. To adapt an analogy of Prof. Stuart's, one is told that a certain boy grows $\frac{1}{10}$th inch in a year, and that he is four feet high; the geologist then argues ten years to grow 1 inch, 480 years for four feet, therefore the boy is 480 years old. On a person who knows more about the boy in question coming forward to inform us that when he was younger he grew much faster, and that after all his age is only ten years, the geologist replies, It may be so, let me see, $\frac{1}{10}$th of an inch in a year, on the doctrine of uniformity, 1 inch in 10 years; no, you are clearly mistaken, 10 years is far too short a time, the organic processes of growth could not possibly have occurred in this time. I grant you my own calculation is not rigorously exact; let us say then our boy is but 400 years of age.——

Is this an unjust parallel?

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of rest, as the following fact illustr
the upper light-house at Tayport to a
westward, there is a break in the line of cl
uninterruptedly forms the margin of the
occupied by a series of gravel terraces, whi
above the reach of the tide, succeed each
hill-sides in rises of from five to ten feet, an
is equal in height to two or three of these
that it must have formed the shore-line duri
of the land to which they bear testimony,
line still. But whether the land rose *per s*
terrupted gradual motion, the sea has left
presence in the form of a line of great cliff
along all the hills, between 150 and 200 fee
of the Ordnance Survey. In colouring the
have adopted the higher level, in order to
the district when the Kames were covered by

That these waterworn gravels and sands
suggested, ancient deposits of the Tay, is, I th
late Dr. William Rhind made a careful esti
the estuary, and found that seventy-five per c
fragments of the rocks along its margin; wh
the constituents of the Kames are nearly all f
indeed little doubt that we owe to the anci
duction into this district of the materials wh
As they slowly drew back over the lowl
gradually buried hill and valley under a thi
which they carried on their surface, with
and granite from the Highland mountains with
and Old Red

It is evident from the presence of the raised gravel beaches previously described that after the final retreat of the glaciers, the land of this district must have been submerged, or, which is much less probable, had risen as the glacier withdrew towards the mountains; at any rate, whether it went down mantled with moraine matter and then rose again, or simply rose out of the sea after the ice-sheet had for ever withdrawn from its shores, foot by foot every part of it would successively form the sea-beach, at first or at last the sea-beach of the mainland, but for the most part of an archipelago of little islands through which the waves of the North Sea rolled towards the hills of Angus and Perthshire. We can readily imagine how that old ocean would sweep the stones left by the ice against the rocks and over each other, rolling them backwards and forwards over its changing beach, wearing and rounding them, and spreading them over its bed, the lighter fragments, the fine gravel and sand, away out in its motionless depths, the larger pieces being deposited nearer the shore, while great boulders would scarcely be moved at all.

Thus, I think the various peculiarities of the construction of the "Kames" may be accounted for. The great mounds of large unstratified stones, the "Castle Hill" and neighbouring heights, are close to the shore of the islands represented by Newton and Wormit Hills, in a channel where the waves of conflicting tides would toss them constantly to and fro, and so prevent anything like orderly stratification, just as we find to be the case on the beach of any exposed part of our coast. Leaving these heights in either direction, we descend into what was the depths of that sea, and find, as we would naturally expect, that in a general way the further we recede from the old sea-shore, the finer are the materials which composed its floor and the more orderly their arrangement.

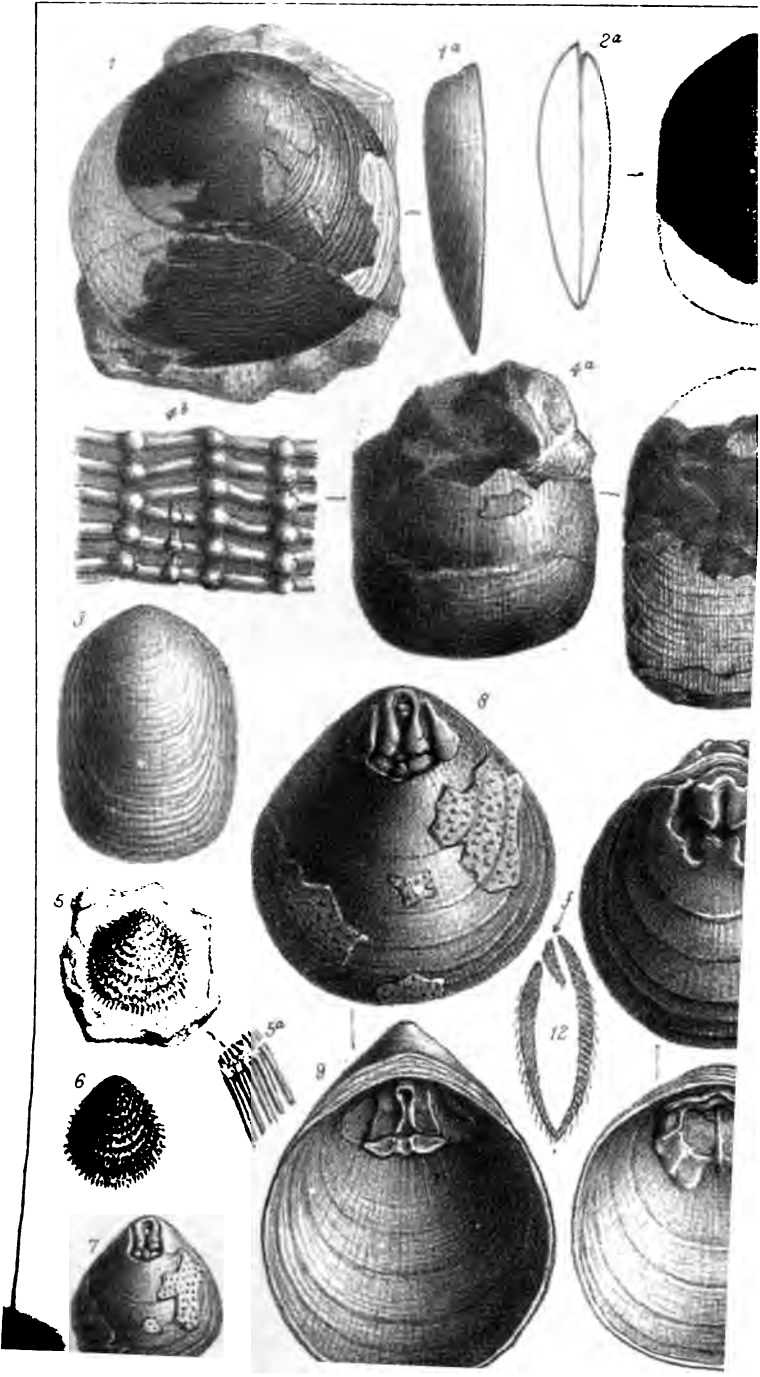
Having thus explained the source and arrangement of the materials which form our Kames, we naturally come to the question of their varied forms. How can we account for the form of the lofty "Castle Hill"? round the base of which, during the construction of the railway, were found traces of an artificial ditch containing black earth and fragments of human bones, pointing to bygone times and struggles when its steep gravelly sides formed a strong position of defence. What force moulded those billow-like ridges that roll round it on all sides as if mimicking the waves of the ocean. Or, more puzzling still, whence this great flat-topped plateau with its angular precipitous side, stretching along the valley like the earthworks of some race of giants? A tolerably careful examination of many of the slopes and hollows has convinced me that the only answer is, Rain and rivers have shaped them all! When the land rose out of the sea, the re-arranged glacial moraine matter would form either a gentle seaward sloping plain from the top of its highest ridge to the sea-level, or, what is more probable, it would form a series of successive terraces or steps similar to what we find between Newport and Tayport. The moment either the whole or part of it was exposed to atmospheric influences, the wasting action would begin; the rain falling on it would soon find or form little channels, which would grow to small and then larger streams as they ran seaward; great streams like the Motray would soon cut deep and broad courses, continually widened and lowered as the stream wound backwards and forwards on its tortuous seaward way. During a great part of the time that has elapsed since the elevation of the land, the Motray has evidently confined its channel to the north side of its valley, scooping out a broad and deep hollow, leaving the great flat-topped Kame at Straiton to record the vast amount of matter it has excavated, its fortification-like front being due to indentations caused by the windings of the river, which at present flows close to the foot of this great terrace. While a large stream like the Motray cleared out a broad plain, tiny rivulets cut narrow but ever-deepening channels, the loose rubbish sliding down their banks frequently compelling them to change their courses, and so isolating the various mounds and ridges, the rain falling on the loose materials would readily obliterate any appearance of vertical cutting, and so form the rounded tops of the cones and backs of the ridges.

Occasionally the Kames present forms so peculiar that it is difficult to realize that rain and running water alone have shaped them; but in every doubtful case a careful examination of the surroundings satisfied me that they have been moulded by this action and no other. One feature in particular I found very puzzling, viz. the small lakelets that often occupy the deepest hollows among the Kames, it being difficult to imagine any force that could hollow out lake-basins, operating here; and as the action of either running water or the waves of the sea would necessarily leave at least one side of the hollow lower than the centre, one solution that presented itself was that the bottoms of the hollows had somehow sunk; but all the observations made were by no means confirmatory of the hypothesis, it being quite apparent that a hollow through which no stream had flowed must have been filled up by matter washed down from its banks by the rain; indeed not long ago one of these pools was almost completely filled up by the action of an unusually heavy fall of rain in a single night. The solution of the difficulty is, however, simple enough; the pools are found in oval-shaped hollows, separated from each other, as well as from the drained areas, by comparatively trifling barriers; their oval hollows are the wider parts of the miniature valley of some vanished streamlet, while the barriers which block up their ends, and so form them into basins, are the narrower parts of the valley partially filled up by gravel washed down from its banks, the narrower parts being of course much more readily filled up than the wider. Other similar little difficulties as readily disappeared upon a closer acquaintance with them, leaving no doubt in my mind that the remarkable forms of the Kames are the ordinary every-day work of subaerial denudation, not the product of cataclysmal waves of ocean, nor of glacier nor iceberg, nor of abnormal sea-currents, but by the unobtrusive unhasting unresting influence of the rainfall.

In conclusion, I will briefly re-state the argument of the paper:—

1.—*The mounds, ridges,* and terraces of sand, gravel, and shingle,

Geol. Mag. 1877. NEW SERIES Decade



del. et lith.

SILURIAN BRACHIOPO

the so-called "Kames," owe most of the materials of which they are composed to the ancient glaciers.

2.—These materials were spread over the bottom of the sea when it was at a higher level than at present, and in the ordinary *familiar* course of nature.

3.—The "Kames" owe their present forms not to any abnormal action of the elements, but are the result of the same denuding agencies that are at present in operation.

III.—NOTES ON FOUR SPECIES OF SCOTTISH LOWER SILURIAN BRACHIOPODA.

By T. DAVIDSON, F.R.S., F.G.S., etc.

(PLATE II.)

Genus SIPHONOTRETA, De Verneuil.

Of this remarkable genus several species from the Lower Silurian rocks of Russia have been well described and illustrated by Eichwald, Pander, de Verneuil, Kutorga, and others, to whose works and papers the reader is referred.[1]

In 1849 Prof. Morris described a species from the Upper Silurian or Wenlock Shale, near Dudley, to which he gave the name of *Anglica.*[2] In 1851 Prof. M'Coy made us acquainted with a much smaller species, *S. micula*[3] which abounds in the Llandeilo flags of various English, Scottish, and Irish localities.

About two years ago Mrs. Gray, an indefatigable collector of Scottish Silurian fossils, to whose liberality I am deeply indebted, discovered in the Caradoc Limestone or Shales of Craighead Quarry, in Aryshire, several incomplete examples of a third species which she kindly placed in my hands for description and illustration.

It is not, however, possible, from the crushed and fragmentary condition in which these specimens have been found, to describe the shell completely, or to refer it, with any degree of certainty, to the Russian species already noticed. It will consequently be better, I think, to give to this Scottish species a provisional separate designation.

1. SIPHONOTRETA SCOTICA, n. sp. ? Pl. II. Figs. 5, 6.

Shell oblong oval, anterior half broadly rounded; posterior half tapering (in the ventral valve) into an acuminated beak, perforated at its extremity by a small circular foraminal aperture. Valves moderately convex and marked with numerous concentric ridges, from which fringes of closely-packed adpressed spines take their rise, which, although more numerous, partake of the character of those figured by Kutorga in pl. vi. fig. 2*b*. of his Memoir already quoted.[1] These tubular spines measure about one line in length and are seemingly straight and smooth, and do not, any more than those figured by Kutorga, show that peculiar moniliform character so well described and figured by Morris in the much longer spines of his *Siph. Anglica*. Mrs. Gray's largest specimen would not exceed seven lines in length by six in breadth, and has much the general shape of young specimens of *Siph. unguiculata*.

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[1] Eichwald, Zoologia Specialis, vol. i. p. 274, 1829. Von Buch, Beiträge zur Bestimmung des Gebirgsformation Russlands, 1840. Kutorga, Ueber die Siphonotreteæ, 1848. De Verneuil, Geol. of Russia, vol. ii. 1845. Davidson, British Fossil Brachiopoda, vol. i., Introduction, p. 131, 1853, and vol. iii. Sil. Mon. p. 75.

[2] Morris, Annals and Mag. Nat. *Hist.* vol. iv. No. 23, p. 315, Nov. 1849.

[3] *M'Coy, Annals and Mag. Nat. Hist. vol.* viii. p. 389, 1851.

Before dismissing the subject of the structure of *Siphonotreta*, I

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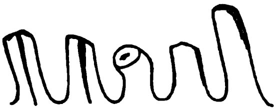
[1] Prof. W. King has kindly favoured me with the following remarks he had made on the shell and spines of one of the Russian species:—"The valve of *Siphonotreta*, as stated by Kutorga, consists of a dermis of a horny nature, an inner perlaceous layer, and an intermediate one of considerable thickness, and containing calcareous matter. Probably an analysis would determine the presence of phosphate of lime in the valves, as in those of *Lingula* and *Discina*. The dermal layer, the only one that could be tried, slightly effervesces on the application of acid: the same test, however, discloses abundance of lime in the casts of the fossils. Morris has noticed that the valves have a distinctly 'perforated structure'; also that their outer surface is ornamented with numerous tubular spines, generally arranged in a very regular order, leaving, when broken off, slightly projecting hollow tubercules in their place. He does not mention that the spines are continuous with the perforations; but it may be inferred that this peculiarity was not unsuspected by him. The spines in the specimens of *Siphonotreta unguiculata* under observation are only preserved on portions of the valves near their margin; elsewhere their presence is indicated by minute tubercules or pimples. It was these that led De Verneuil to characterize the shell 'a surface chagrinée.' Between the pimples the surface is marked with fine raised reticulating lines. The tubularity of the spines is indicated by an opaque medial line in the midst of their subtranslucent substance (Fig. A.). The spines, when transversely truncated, exhibit very clearly the position of their contained tube; besides, the pimples frequently show a hollow, corresponding to the tube, in their centre. The inner surface of the valve is marked with regular cup-shaped depressions (eminences on a cast of it), containing in their centre a minute deep cavity (Fig. B.); which is doubtless continued through the thickness of the valve into the tube of the external spines, but the connexion is not satisfactorily exhibited, evidently through molecular changes which the intermediate layer of the valves has undergone. From the preceding remarks it will be seen that the spinose peculiarities of *Siphonotreta unguiculata*, instead of being simply dermal processes, as is the case in *Discina*, are of the nature of those known to characterize *Productus*, *Strophalosia*, *Rh. spinosa*, and some other Palliobranchs. Whether the tubularity of the spines in *Siphonotreta* and the fossils just named, is homologous to the perforated shell structure common to *Terebratula*, *Spiriferina*, and other genera of their class, is a question which does not seem to be sufficiently advanced for determination at present. Often the hollows on the inner surface of the valve contain a dark-coloured infilling; and frequently they are charged with a greenish subtranslucent mineral substance, which certain Canadian Eozoonites, unnecessarily anxious to meet with a case of the kind, would probably regard as serpentine; but without denying the possibility of such a methylised product occurring as a fossil infilling, the substance in question seems more likely to be one of the numerous varieties of glauconite; or possibly, it may be related to apatite, and derived from the phosphate of lime of which the shell structure of *Siphonotreta* was to some extent originally composed. The hollows in the pimples, on the outer surface, are also often filled with the same substance; which fact may be offered as further supporting the conclusion that there is a tubular connexion between the inner and the outer surface of the valves."

Fig. A. × 105.



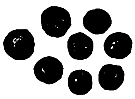


Fig. B. × 105.

may mention that although the external character of the genus and some of its internal ones have been carefully described, the questions as to its affinities and muscular arrangements offer great difficulties which the material in our possession does not allow us to solve in a satisfactory manner. The form and character of the perforated beak has been well described by Kutorga, and in pl. vi. fig. 4*d* and *c*, and in fig. 7*c* and *d*, are drawn internal casts of *Siphonotreta unguiculata* and *S. fornicata*, in which it is seen that the muscular scars occupy a small space in the umbonal portion of the interior of both valves; but he fails to define these impressions or explain their functions.

During his recent visit to Brighton I asked Prof. F. Schmidt if he could procure me a sharply-marked and well-preserved internal cast of *Siphonotreta unguiculata*, and on his return to Reval, in his usual kind and obliging manner, he lost no time in sending me the cast (Fig. 7) from the Lower Silurian Rocks (his "Schicht 1*d*") of Reval. Of this cast Figs. 8 and 10 are carefully enlarged representations, 9 and 11 gutta-percha impressions taken from the cast, and likewise enlarged, to show in an approximately correct manner the character of the interior of both valves of the shell itself.

After having made these drawings, I submitted them and the cast to Prof. King, in order to have likewise his valuable opinion on the subject; but although the impressions were tolerably well defined, neither of us could interpret them as we might have desired, and more material will be required before that can be satisfactorily achieved. It is quite evident, however, that the genus belongs to King's division, *Tretenterata*, or to that group of Brachiopods, such as *Lingula*, which are destitute of an anal aperture; and it appeared to both of us that the specimens we have been able to examine favour the idea that *Siphonotreta* is more closely related to *Obolus* and *Discina* than to *Monomerella*, though the last genus may still lay some claim to being its kindred. We all know that *Obolus* has a large muscular scar (*a*) close to and at each end of the edentulous hinge in both valves; each scar is separated from another one (*b*) much elongated by a ridge (*c*). Prof. King thinks the two ridges are present in the valve of *Siphonotreta*, and though the evidences on the valve are perplexing, there being appearances of two scars, or a compressed one, situated at the origin of the ridge, the evidence is somewhat in favour of the scar belonging to or representing the scar (*a*) in *Obolus*. That in *Obolus* the large scar (*a*) is well pronounced, lying outside of and distinctly separated from the ridge. In *Discina* there are two posterior adductor muscles, leaving strong scars similarly situated, and which Prof. King considers to correspond to those of (*a*) in *Obolus*. If this is a correct interpretation, as regards the scars at the origin of the ridge in *Siphonotreta*, the affinities of this genus, as above stated, will be more on the side of *Obolus* and *Discina* than of *Monomerella*. *Monomerella*, as has been stated elsewhere by Prof. King and myself, does not appear to have posterior adductors, but they may have been atrophied, thus causing the genus to be a little more removed than *Siphonotreta* from *Obolus* and *Discina*.

The muscular impressions in *Obolus* are more spread out than in either *Discina* or *Siphonotreta*, and Prof. King thinks that this difference appears to be explained thus: the latero-cardinal scars in *Siphonotreta* are more crowded together than they are in *Obolus*, and the central projecting portion of the undercut 'spectacle'-like impressions in *Obolus* advance more to the anterior margin of the valve than the corresponding impressions in *Siphonotreta*.

2. LINGULA CANADENSIS, Billings (?). Pl. II. Figs. 4, 4*a*. *b*.

Lingula Canadensis, Billings, Geological Survey of Canada, Fossils, vol. i. p. 114, fig. 95, June, 1862.

Of this large and beautiful *Lingula* Mrs. Gray has found one incomplete example. It was obtained from the Breccia-conglomerate of Balcletchie, near Girvan, in Ayrshire. This conglomerate rests upon the rock at Balcletchie, which some geologists have considered to be of Llandeilo age.

It is not possible to describe the complete shape of the fossil, because the two anterior thirds of its valves are alone preserved. It however, so nearly agrees in size, shape, and sculpture with the fossil described and figured by Billings from the Hudson River group of Anticosti, that we have thought it preferable to leave it provisionally under that designation.

It is of a quadrate or sub-pentagonal elongated shape, posteriorly obtusely acuminated, broadest anteriorly; the sides are almost straight, front very slightly convex with broadly rounded angles. The smaller valve is much flattened anteriorly, and but slightly convex posteriorly or towards the beak. The larger valve is very

Sheet.[1] This paper will doubtless call forth a number of equally elaborate answers: and this is well. But if Mr. Goodchild has a fine goose fattened on the Limestone terraces of Wensleydale, I have an equally fine gander reared on Gritstone terraces in Derbyshire: and if a frozen sauce of regelated snow from wintry storms of the Great Ice Age is good for one, it is equally good for the other. Dropping metaphor, there is no difference between terraces, mainly of limestone, in Wensleydale, and other terraces, chiefly of grit, that are found over all the Millstone Grit area of South Yorkshire and Derbyshire, saving that while limestone predominates in the one, beds of grit do in the other. If an ice-sheet carved out the terraces of the Limestone Dales, it equally did those of the rest of Yorkshire, Derbyshire, and, may I not add, of Cheshire and Staffordshire; yet no sober-minded man, looking at these terraces, over so large an area, rising and falling with every change in the inclination of the beds, but ever following the dip and keeping to the bedding-planes, could possibly suppose that they were carved out by ice-sheets. What in the name of reason is to cause a great grinding ice-sheet, of whose vaunted powers we have heard so much of late, to keep to a bedding-plane; much more to rise and fall with the dip of the beds? Add to this all-sufficient objection to Mr. Goodchild's theory the fact that over a great portion of this terraced area there is not a particle of drift or a single ice-scratch, that has yet been discovered, to bear witness to the fact of any ice-sheet having been there at all.

The fact that the terraces conform to the bedding is to my mind conclusive against the Glacial Erosion theory; but, as Mr. Goodchild actually thinks this an argument in favour of his theory, allow me to ask him how he reconciles this accommodation of glacial action to differences of hardness with the power of ice to smooth and round off gnarled crystalline rocks, or to scoop out rock-basins in tough Silurian slates quite irrespective of degrees of hardness. It seems quite clear that ice cannot behave at one and the same time in such opposite ways; if it is guided in its course by such differences of hardness as occur between limestone and sandstone, or these and shale, it cannot scoop out rock-basins in total disregard of such differences; and if it can scoop out such rock-basins, it will not be so affected in its course as to carve out bedding terraces.

As for the lines of swallow-holes along the junction of the limestone with the overlying shale, the fact that these exist only along this line of junction, and are not equally to be found over the bare surface of the limestone, is no argument against the shale bank having been eaten back by ordinary atmospheric agencies; for it is just to the very presence of the shale that the marked lines of swallow-holes owe their existence; the actual hole in the limestone is generally a very insignificant matter, mostly a mere ordinary joint. The marked swallow-holes are in the shale itself, and are due to the soft shale crumbling away and falling into the open joints below, and so giving rise to a funnel-shaped hollow much wider at than at bottom. Cut back the shale bank a hundred feet along length of the terrace, and another series of pits will begin to , while nothing will remain to mark the former position or tence of the present line of holes.

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[1] "Glacial Erosion," by J. G. Goodchild, GEOL. MAG., July, 1875, Dec. II. Vol. II. p. 323.

he Ice-hobby has been pretty well ridden of late; it shifts the h's centre of gravity, causes the ocean to rise and fall, sinks down inents into the molten magma on which they float, creeps out the north over hundreds of miles of flat; marches over mouns like nothing, like the old soldier's nose in the fairy tale; grinds owder the hardest rock, scoops out basins indifferently in soft cene gravels or crystalline schists, and yet has so little shearing e that the upper and under parts move often in diametrically osite directions; it eddies round like a whirlpool in water, turns k upon itself with a kind of perpetual motion, hollows out combes nountain flanks (and every hill-side that is not convex is a combe), now yields to the soft allurement of a bed of shale. One is pted to ask what feat it will perform next; perhaps it will be nd to be the cause of wide-spread metamorphism. But we shall

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V.—ON THE TERMS "BERNICIAN" AND "TUEDIAN."

By G. A. LEBOUR, F.G.S. London and Belgium, F.R.G.S., etc.;
turer in Geological Surveying in the University of Durham College of Physical Science, Newcastle-on-Tyne.

T the London Meeting of the North of England Institute of Mining Engineers last June, I read a paper in which I vened to put forward a scheme of classification of the Carboniferous ks of Northumberland which I believed to be both a natural and onvenient one. The leading features of this scheme will be best derstood by glancing at the following table with which my paper ncluded.

TABLE—CORRELATING PROPOSED DIVISIONS WITH OLD ONES.

ORTHUMBERLAND, PROPOSED.		SYNONYMS.	
UPPER.	COAL MEASURES.	Coal Measures.	Upper Carboniferous.
	GANNISTER BEDS.	Gannister Beds.	
	MILLSTONE GRIT.	Millstone Grit and Carboniferous Limestone in part.	Middle Carboniferous.
LOWER.	BERNICIAN.	Yoredale Series and Calcareous Group in part.	
		Scar Limestone Series and Calcareous Group in part, *plus* Carbonaceous Group.	Lower Carboniferous.
	TUEDIAN.	Calciferous Sandstone, or Tuedian, or Valentian, and Upper Old Red Conglomerate in part.	

The chief points insisted on by me were,—1. The division of the Carboniferous rocks into Upper and Lower only,—2. The recognition of the Gannister Beds and Millstone Grit only as subordinate members of the Coal-measures Group,—3. The adoption of the names Bernician and Tuedian for the two great series constituting the Lower Carboniferous, and including all the rocks from the Yoredales to the Upper Old Red Conglomerate, both inclusive. The reasons for these changes need not be repeated here.

When, in the discussion which followed the reading of this paper, Mr. Warrington Smyth condemned the coining of new names for divisions of local value, I had little to say in answer to the charge, since I was conscious of having a year before been guilty of proposing the word "Bernician" at the Bristol Meeting of the British Association and in the GEOLOGICAL MAGAZINE. The words Coal-measures, Gannister Beds, and Millstone Grit were as old as the hills, and the only expressions that could be called in question were "Bernician" and "Tuedian." Of these the latter was proposed in 1855 by Mr. George Tate, of Alnwick, who up to about ten years ago was perhaps the only man who had studied the Calciferous Sandstone series south of Scotland. I therefore could only feel responsible for the term "Bernician," and with an author's modesty I refrained from then giving that name all the praise which I felt it deserved. I am now no longer in that embarrassing position, and can now say (what I then thought) that the word is an excellent, most appropriate, and convenient one, and that it is well fitted to come into general use.

The fact is that it turns out that I am not the originator of "Bernician." Within the last few weeks I have discovered this, and hasten to throw the responsibility of its creation on the shoulders of one whose reputation is far better able to bear it. The term was proposed in 1856 by the late Dr. S. P. Woodward, who, at p. 409 of his "Manual of the Mullusca," thus defines the Carboniferous portion of the geological column:

IV. [Carboniferous]	8. Bernician.	Carboniferous Limestone (Shale and Coal).
	9. Demetian.	Coal-measures (Millstone, Grit, Coal, etc.).

Nothing more is said as to these terms, and except in the "Manual" they have not been reprinted anywhere to my knowledge until 1874, when Karl Mayer printed his table of sedimentary rocks, in which he characterizes the Carboniferous system as follows:

III. KOHLEN-GEBILDE.

B. Demetian (Woodward, 1859)	I. *b.* S. Etienner Schichten	(Mayer, 1874).
	I. *a.* Stadtberger	" "
A. Bernician (Woodward, 1859)	II. Elberfelder	" "
	I. Viséer	" "

The date 1859 is a mistake. It was on seeing this table a few days ago that my attention was drawn to Dr. Woodward's use of the term Bernician. As no explanation of this term is given in the Manual, in which, indeed, it appears but once, it is perhaps not surprising that it should have escaped general attention. That Dr. Woodward should have proposed it, that Dr. Karl Mayer should,

r the lapse of many years, have adopted it, and I may add, that
hould have occurred independently to a writer in 1875 ; all this
good *primâ facie* evidence that the name has something to recom-
nd it. Before discussing its merits, however, it may be well to
nsider what other names it was to take the place of. These we
y divide into two sets—A, those which have a lithological sig-
ication, and which only constant usage can make us tolerate,
d B, geographical names.

A.—*Lithological names*:

1. Mountain Limestone.
2. Carboniferous Limestone.
3. Sub-Carboniferous.
4. Productus Limestone.
5. Fusulina Limestone.
6. Anthraciferous Series (in part).
7. Carboniferian (in part).
8. Blue Limestone (Calcaire bleu).

B.—*Geographical name*:

1. Condrusian (in part).

f the lithological names No. 1 is respectable by reason of its age,
t it is singularly inapplicable to the numerous districts where the
lcareous parts of the Lower Carboniferous are conspicuous by their
cessive thinness or even by their absence. No. 3 is usually limited
America in its application, and would, I think, have no chance of
ing naturalized with us ; besides, even American geologists while
ing it frequently condemn the term. No. 5 is limited in its value,
it can only be properly used in connexion with the presence of
sulina, and even then is decidedly a bad term, since that Fora-
inifer is now known to range into the Permian, if not higher
ill. No. 6, including as it does large series of beds of doubtful
e, some of which are not Carboniferous, would, I think, find no
pporters, and although still much used on the Continent, is un-
own in England. No. 8 is again a French name, formerly much
vogue, but as it is the most strictly lithological of the lot, it must,
venture to say, be also the worst of all. Against Nos. 2, 4, and 7
ere is not much to say, their use is well understood, but the facts
t remain, that the series is sometimes devoid of limestone, fre-
ently yields no *Producti*, and often contains no Coal.

It is curious that as against the eight chief lithological synonyms
Bernician, I can find but one geographical one which has ever
en in common use. This name, "Condrusian," was proposed
André Dumont in or about 1843, and if equally good would
erefore have priority over Dr. Woodward's term. Condrusian,
wever, was made to include a great deal more than the marine
ower Carboniferous. It comprised Devonian rocks also, and the
ondroz, whence the name is taken, is now associated in the minds
geologists more with the latter than with the former. Under
ese circumstances, and considering also that the term was probably
eant as a strictly local one by its author, it will be well to place it
ith the eight preceding names as being each and all liable to mis-
terpretation, although no doubt blind custom will perpetuate the
se of some of them—probably the worst.

Having endeavoured to show the disadvantages under which
bour the rivals of "*Bernician*," it is time to consider the advantages
f that name. In the first place it is geographical, it is derived from

that part of Britain in which the beds which it denotes are most largely developed, where especially the characters marking the series elsewhere are found associated, as, I believe, they are nowhere else. There numerous beds of limestone represent the massive calcareous mass of Derbyshire; there occur the Coal-bearing beds of Russia and the *Posidonomya Becheri* shales of the Culm; there the sandstone and grit facies of the Series is most strongly developed; and there finally are the palæontological characters of the Silesian, Belgian, and Scotch series blended in an almost unique manner. These are all qualities which eminently fit Bernicia to be looked upon as a type locality or region. In the second place, the name "Bernician" gives rise to no preconceived notion that experience can prove untrue, it expresses a geographical truth and nothing more.

Dr. Woodward and Dr. Karl Mayer evidently intended to include everything between the Millstone Grit and Devonian under the term "Bernician," whereas in the paper to which I have already referred, and which was purely local in character, I retained the name "Tuedian" for the Calciferous sandstone series. I, however, also showed that the line of division between Tuedian and Bernician was a variable one, that the one series ran into the other as it were, and that moreover the base of the Tuedians (in which I include the so-called Upper Old Red Conglomerate) in a similar manner ran into the Old Red, and was not sharply divided from it. The former of these points I again urged more strongly at the Glasgow Meeting of the British Association in September last. The question left to be decided is this:—Is "Bernician" to be distinct from Tuedian, or is it to contain it as a subordinate member? This is not an easy question to answer at present, but I incline to think that the last will be nearer the truth, and that in time the Tuedians will come to be looked upon as passage-beds from Old Red to Bernician, parts of which may be claimed by both.

The word Tuedian which I employ is in much disfavour in Scotland. The only objections to its use that I have heard, however, are,—first, that the "Cement-stone and red-sandstone series" occurs throughout all the Carboniferous districts of Scotland, and is in the Lothians much more typically developed than in the Tweed Basin; and, secondly, that the name "Calciferous sandstone series" given to these rocks by Maclaren in 1839 is a good one.

To the second objection it may be at once replied that as a purely lithological term of necessarily only local application, exception might well be taken to Maclaren's name even were it not so dangerously similar to the Potsdam "Calciferous series" of North America, or even to our Oxfordian "Calcareous grit." The first objection is a stronger one, but it does not show that "Tuedian" is a bad name—only that a better might be invented. If a better one had thus been proposed before 1855, so much the better; but "Tuedian" came out then, and if not the best possible is yet a geographical name, and not a bad one in itself; is it not better to retain it, whatever the classificatory value of the beds which it represents may prove to be?

n conclusion, may I venture to hope that before long some rules ›ecting stratigraphical nomenclature may be promulgated which regulate in some way the issue of new names. It will surprise ıe of your readers when I say that I have lying before me a list nore than four thousand stratigraphical names.

NOTICES OF MEMOIRS.

—The Tropical Forests of Hampshire: Being the substance of a Lecture delivered in connexion with the Loan Collection, South Kensington, by J. S. Gardner, F.G.S., Saturday. Dec. 2nd, 1876.

ENGLAND at the present time has a climate far from tropical, but the time to which I refer was when the palm and spiceants flourished here, and when the climate may rightly be spoken as tropical, not in a poetical or metaphorical sense, but actually. ıe data on which our inferences are based are the fossil leaves ıich we find in the clays of the south of Hampshire. Out of the ıny thousands obtained during many years, I have selected some hich have been exhibited in the Loan Collection. Some have also en brought in illustration of our subject to-night. Collections of ıves from this spot and from Alum Bay have also been made by r. W. S. Mitchell, M.A., and others, and are now preserved in the ritish Museum.

It is the district immediately along the line east and west of ›urnemouth which I have specially examined. The beds which cupy this area are of the age of the Lower Bagshot. Above the ıgshot series we have the Bracklesham beds full of marine forms; e Barton beds, also full of marine forms, but telling a tale of a fferent sea; the Headon, Bembridge, and Hempstead series, with any repetitions of marine and fresh-water conditions, indicative long lapses of time. There is, too, the whole Miocene period, which we have no trace in this district, but which we believe ›m continental evidences was of vast duration. Then, too, there llowed periods of immense length, during which England underent its latest Glacial epoch; after that the time during which the iver Valley gravels and Brick-earths were formed. While, therere, we speak of these beds as almost the youngest of the geological ries, they really belong, when measured in years, to periods of an calculably remote past."

With the help of diagrams and pictures Mr. Gardner traced e series of beds from Corfe to Wareham, Poole, and Studland, ıd then back from Studland to the mouth of Poole Harbour, and ong the shore past Branksome to Bournemouth, and on to engistbury Head, the physical features and general appearance the country being described. The alternations of clays, sands, ıd pebble beds, as they appear in the cliffs, and the pipe-clay iggings, were especially referred to, and Mr. Gardner then connued:—"No order of arrangement is at first apparent in these eds, but *by traversing the sections* many times and studying them attentively there is, it seems to me, a very well marked and recognizable sequence. I will now indicate the sequence. It has never been laid before the geological public until now, and it is possible, as is often the case with new work, that there may be some objections raised to it. I can only tell you, however, that after discussing the matter with geological friends, my own convictions are strengthened." The author then referred to his diagram of the district. "This lower fresh-water series is seen in the neighbourhood of Corfe, and forms part of the cliffs at Studland. It is characterized by abundance of pipe-clays, and forms a thickness of possibly 200 feet. The middle fresh-water series, also met with near Corfe and at Studland, forms the whole thickness of the cliffs between Poole Harbour and Bournemouth. We thus have a magnificent section four miles long and 100 feet in height. Branksea Island is also formed of this series. Their entire thickness cannot yet be accurately estimated, but may be put down at some 300 feet. They are characterized by the fact that the clays contained in them are usually brick-earth.

The next series above is a marine series, and is some 400 ft. or 500 ft. thick. The base beds are dark sands and clays, succeeded by pebble beds and sands, then more sandy clays with pebbles, and ending with a thick deposit of white sands. This marine portion of the series occupies the cliffs between Boscombe and High Cliff. It is the middle fresh-water series which is so rich in the clay beds containing fossil leaves. These leaves are found in various conditions of preservation. In most cases the impression only of the leaves in the clay is met with, but in some cases they are so well preserved that the actual substance has been retained, although chemical changes have altered its composition, and it will peel off and blow away. In some of the clays the masses of leaves are so decaye that they cannot be recognized, and are not worth our collecting Where the preservation is good, we can readily distinguish th various original textures of the leaves by comparing their genera aspect and colour both among themselves and with existing form For instance, those which are thick, such as evergreens; thin, convolvulus; hard, such as oak: or soft, such as lilac; or eve velvety, such as the common *Phlox*, can all be recognized. The colours, in most of the beds, vary from buff to brown, and I ne hardly tell you that in no case have we any of the green colouri of the leaves preserved. Whilst these various shades of dark bu and browns are in many cases the result of chemical change that h taken place after the leaf was covered up, yet I believe that in ma cases this change had occurred, at least partially, before the coveri up, just as we saw a few weeks ago the changed colours of the fall leaves of autumn. In the darker clays the remains are black a completely carbonized; where this is so, the finer venation is ind tinct and the remains difficult to save, so that we may discard th unless the outline of the leaf is of unusual form. The darker brow I take it, indicate hard and evergreen leaves; for instance, t laurel-like leaves are always of a deep colour, whilst both the th d the succulent leaves are always of light colour, as in the leaves hich we suppose to be fig, some species of *Smilax*, etc. No other lours have been met with, with one remarkable exception; frag-ents of a reed-like plant are found of a deep violet, staining the rrounding clay mauve for a considerable distance." The shape, e venation, and character of the margin of the leaves being the oints by which comparisons are made with the leaves of trees now xisting, were described at some length, and the difficulties of uccessfully making the comparisons were referred to. Among thers the following fossil forms were mentioned as having been letermined with but little doubt. Feather and fan-palms, *Dryandra*, beech, maple, *Azalea*, laurel, elm, acacia, aroids, cactus, ferns, onifers, *Stenocarpus*, and plants of the pea tribe, together with any others. "This question may perhaps have presented itself o your minds—how is it possible that the tropical forms of which e have spoken, such as the palm, aroids, cactus, etc., could have rown alongside of the apparently temperate forms, such as the ak, elm, beech and others? Time does not allow that I should go t any length into the explanation of this; but I may just remind ou that in the long geological record of the beds found in England, here are to the geologist unmistakable indications of many changes n climate. Further, astronomers, having calculated the path of the evolution of the earth in ages past, tell us that in recurring periods, ach hemisphere, northern and southern, has been successively subect to repeated cyclical changes in temperature. There have been or the area which is now England many alternations of long periods f heat and cold. Whenever the area became warmer, the descendants of semi-tropical forms would gradually creep further and further orth, whilst the descendants of cold-loving plants would retreat rom the advancing temperature, *vice versâ*. Whenever the area ecame gradually colder, the heat-loving plants would, from one eneration to another, retreat further and further south, whilst the old-loving plants would return to the area from which their ncestors had been driven out. In each case there would be some ingering remnants of the retreating vegetation (though perhaps xisting with diminished vigour) growing alongside of the earliest rrivals of the incoming vegetation.

Such is a possible explanation of our finding these plant-remains ommingled together. It must, too, be borne in mind that it is not o much the mean temperature of a whole year which affects the ossibility of plants growing in any locality, as the fact of what are e extremes of summer and winter temperature. For example, one lace may have a mean winter temperature of 50°, and a summer ne of 70°; whilst another place might have a mean winter temerature of 20° and a summer one of 100°, and yet both have a mean nnual temperature of 60°.

In Cornwall the maiden-hair fern grows in sheltered localities, ecause the winter temperature never sinks to the point that would ause its destruction. Again, at that most charming spot in the est of *Ireland, Glengariff, the Arbutus* still forms an abundant underwood; and the Irish 'Film-fern' (*Hymenophyllum unilaterale*) flourished in many favoured spots until quite recently, when the modern Eccles Hotel has retained tourists too long in the district, who have ruthlessly carried off, as reminiscences of a pleasant holiday, this which was one of the most attractive features to the botanist."

After mentioning that in the two lower fresh-water series there are no animal remains but what have been blown in, among them insect wings and the earliest known English feather, the lecturer went on to speak of the physical conditions under which he supposes the beds were formed. He said that he regarded a river flowing from west to east as having deposited all these beds in a valley of from seven to ten miles, which it had made, and showed a picture of the restoration of what he supposed the view was like. The foreground of the picture was made up of plants from Mrs. J. E. Gardner's conservatory, being the nearest known living representatives of the fossil plants.

A block opened before the audience proved fortunately a good one and crowded with leaves. Some experiments were made during the lecture showing that there is in the decomposed granite enough iron to account for the colours of the clay.

II.—Note sur un nouveau genre d'Entromostracé fossile provenant du terrain carbonifère des environs de Saint-Etienne (*Palæocypris Edwardsii*), par M. Charles Brongniart.

MANY traces of the former existence of Entomostraca are to be found in the different geological formations, their carapaces being often admirably preserved and exhibiting all their external markings, whilst every vestige of the animals themselves has been entirely removed. Much uncertainty, therefore, exists concerning the exact zoological affinities of these fossils, and Palæontologists he anterior portion of the body is curved, and in this region is ituated the eye, which is large, black, oblong, very prominent, and laced much lower than in *Cypris*. The upper antennæ, inserted mmediately below the eye, are long, setigerous, and composed of five joints gradually diminishing in size. Each of these joints bears on its upper part a tolerably long bristle, the fifth, however, is furnished with two. The lower antennæ consist of six joints, of which the second, third, and fourth carry each a single bristle, whilst the sixth has a tuft of four.

Like all true *Cypridæ*, it possesses two pairs of feet. The first pair slender, composed of four joints and terminating in two curved claws; the second stouter, and, like the first pair, made up of five joints, the last terminating in two long curved claws; but it is also furnished with two well-developed bristles, which spring from the summit of the first joint.

The jaws are not so distinctly visible in this fossil genus as the previously described organs; but M. Brongniart has been able to distinguish in one individual a large mandible which is divided at its extremity into several teeth, each provided with some very fine, short hairs. Another individual exhibits a palpus of two joints, with a pencil of fourteen medium-sized bristles attached to the terminal one.

The post-abdominal ramus is short, stout, and broad at its extremity; in some specimens (probably the females) it bears seven jointed bristles of uniform length, but in others (the males?) it is not so large, and provided with only four short bristles, one of which is longer than the rest. At the posterior portion of the body of the former appear two large black oval bodies, united at their bases, which may be the ovaries.

The author carefully notes the differences existing between the structure of the organs as exhibited in *Palæocypris* and that of the orresponding organs in the recent genera of *Cypris*, *Cypridopsis*, *Notodromas*, and *Candona*, at the same time pointing out that the general similarity between them, as far as their organization is concerned, is the more interesting when the immense interval of time by which their periods of existence are separated is taken into consideration.
B.B.W.

II.—Geological Notes on some parts of West Tropical Africa. By D. O. Leng. From the Rep. Imp. Geol. Instit. Vienna, June 30, 1876.

[Communicated by Count Marschall, C.M.G.S., etc.]

THE rocks along the Okande river are argillaceous slates, gneiss, and mica-schists with garnets, intermixed with subordinate ands of reddish-white quartz. The prevailing rock in the Ashkura egion is a coarse-grained *granite*, containing reddish-white, and equently large crystals of orthoclase, having bright cleavage-lanes,—oligoclase in smaller crystals, white with distinct binary triation,—also biotite-mica in green or greenish-black plates, single r agglomerated into small nodules, and amphibole in single, rather arge, *black, tabular crystals.* In several detached blocks the felspar one department of the science, and to be content with a less perfect grasp of the rest. If in the second part of this publication we should find as broad and comprehensive views of the stratigraphical and palæontological sides of geology, as we have here presented to us of the physical, then we think Mr. Green will be entitled to rank among the select few who may claim an approach to geological omniscience.

The style of this book reminds us somewhat of De La Beche's writings. The reasoning is logical, and the language simple and forcible; but occasionally marred by a certain roughness which jars against the reader's taste. We would in particular instance the constant recurrence, especially in the earlier chapters, of the word "latter," which, even when correctly used, breaks the current of the thoughts, and obliges one to hark back to catch an author's meaning. But when there is no "former" to answer to it, then the phrase is distressing. Thus where (p. 56) we are told that quartz occurs "usually as glassy lumps, which fill up the spaces between other minerals, and are sometimes seen to have moulded themselves on the latter," we are irresistibly led to ask, what the lumps would have been like if they had moulded themselves upon the *former*?

Throughout the book everything is made subsidiary to pure geology. The petrological part is treated from a geological point of view, and rocks, which the petrologist would separate in his museum, are classed together as merely modifications of the same original deposit under different aspects and degrees of metamorphism. Indeed, upon this subject of metamorphism, the author appears to hold stronger opinions than are usual regarding the extent to which it may be carried; and attributes to that agency of our availing ourselves of mathematical analysis. But if)e so, it is better frankly to acknowledge the fact, and not to pt to support or overthrow a theory by a show of numerical ıcy, which has no sound basis to rest upon." This no doubt)e a popular sentiment and a flattering unction to many to be)y one of Prof. Green's ability, that they who cannot calculate ; well off as those who can. But surely Prof. Green will wledge that in all such cases there are extreme limits, which ıantities involved in any problem cannot exceed on one side, l short of on the other, and thus the application of these to the n hand involves no "show of numerical accuracy," but is an t and a real way of deciding, within the possible limits, whether ry be true or false.

Croll's theories of climatal changes are remarkably well ıized in the twelfth chapter, and are evidently favourably ained. Indeed this twelfth chapter strikes us as much more ing than the previous one, which treats of the condition of rth's interior. The one subject has been almost as much conted as the other, although the latter is the older, and has ıt account had the advantage of being attacked by men of reatest power. Yet it is only lately that Geology has contrither share to the data of this great question, and very reindeed, if even yet, that physicists have learnt to perceive he facts of geology cannot bend to the results of physical y, but that, in order to form a true theory, neither can be :d to lord it over the other, and that the requirements of each be equally satisfied.

ery noticeable and most valuable feature in Prof. Green's is the abundance of reference to original treatises and papers. ook might be used as a nearly complete index to the whole ure of that part of Geology of which it professes to treat.

ETHÆA PALÆOZOICA. By Professor FERD. ROEMER. Atlas of 62 Plates. Large 8vo. (Stuttgart, 1876.)

S Atlas of Plates is the first issued part of a "Lethæa geoıostica," which, when complete, will cover the entire ground tigraphical palæontology. The scheme is, on an enlarged and ved scale, virtually a new edition of Bronn's well-known with the great advantage of having the co-operation of several lists of authority in its production. The Palæozoic portion :en placed in the hands of Professor Ferdinand Roemer, of u, whose life-long work among the fossils of the older rocks en successfully carried on in every part of Europe, and in the Vorld as well as the Old. No choice could be more calculated use the highest expectations on the part of geologists and ıtologists, and although we have yet before us only the illusıs of the text to come, still there is enough in the brief preface, choice of fossils, and in the mode of their arrangement, to that the subject is handled by a veteran whose individuality itself conspicuous *even in such matters* as these.

The stratigraphical divisions in which the fossils represented are grouped are purposely the largest that could with propriety be adopted. They are as follows: 1. Cambrian (pl. i., ii.). 2. Lower Silurian (pl. iii.–viii.). 3. Upper Silurian (pl. ix.–xix.). 4. Lower Devonian [Old Red Sandstone] (pl. xx.–xxii.). 4*a*. The same [Coblenz Grauwacke] (pl. xxiii.–xxv.). 5. Middle Devonian [Eifler-Kalk] (pl. xxvi.–xxxi.). 5*a*. The same [Paffrather-Kalk] (pl. xxii.). 6. Devonian, plants (pl. xxxiii., xxxiv.). 7. Upper Devonian [Goniatite beds] (pl. xxxv.). 8. The same [Clymenia beds] (pl. xxxvi.). 9. Culm (pl. xxxvii., xxxviii.). 10. Carboniferous Limestone (pl. xxxix.–xlvi., xlviii.). 11. Coal-Measures (pl. xlvii., il.–lv.). 12. Permian (pl. lvi.–lxii.).

Pre-Cambrian fossils do not find favour in the author's eyes, and such *things* (perhaps this is the safest term!) as *Eozoon* and *Palæopyge* are not depicted on his plates, although it is to be hoped that they will not be as utterly ignored in the text. The term "Protozoic," moreover, which Dr. Roemer attaches to the first plates as synonymous with Cambrian, probably further indicates his views as to the geological evidences of the beginnings of life. The succeeding horizons are very fully represented by figures of fossils from all parts of the world, and of these many will be invaluable from the fact that they are reproduced from works of very difficult access to the majority of students, while others have been drawn from striking specimens expressly for this publication. The plates are lithographed in a bold clear style. quite suitable to the object of the "Lethæa"; but there is considerable difference discernible in the quality of their printing. Some few—such as pl. 39 for instance—

Bostrichopus antiquus, Goldf. The only known and wonderfully perfect example of which was found in the *Posidonomya* schists or Culm near Herborn in Nassau, and is preserved in the Bonn Museum.

Lying before us is another work of Professor Ferd. Roemer's,[1] published several years ago, with all the advantages that can be derived from fine paper, good printing, and beautifully finished plates. It is a handsome quarto monograph of the Fossil Fauna of the Silurian Drift of Sadewitz in Lower Silesia. It would seem absurd to compare the eight splendid plates which illustrate it with those of the "Lethæa," but an examination of both will show how thoroughly they are adapted to their respective objects, and if the latter appear rough and ready by the side of the former, they will lose none of their value on that account.

This Sadewitz Monograph is quite a palæontological and geological curiosity, being the description of a fauna from unknown beds, the fossils forming which were all collected from Drift deposits. Seventy-three species are enumerated, including twenty-five new ones, and a careful study of the group of organisms thus brought together, and of the lithological character of the original matrix still associated with the specimens, led the author to hazard the suggestion that the Silurian rocks which once contained them are to be sought in the Eastern Russian provinces, either in Esthonia or still under the sea in the neighbourhood.

Among the species figured some splendid sponges are very noticeable; such as, *Aulocopium diadema*, Osw.; *A. aurantium*, Osw.; *A. hemisphæricum*, Roem.; *Astylospongia incisa*, Roem., etc., etc.

The position of the Lyckholm beds in Esthonia, which seem to be the most likely horizon whence these fossils were derived is towards the top of the Lower Silurian, between the Wesenberg beds (below) and the Borkholm beds. G. A. L.

II.—COURS ÉLÉMENTAIRE DE GÉOLOGIE À L'USAGE DE L'ENSEIGNEMENT SECONDAIRE CLASSIQUE ET DE L'ENSEIGNEMENT SECONDAIRE SPÉCIAL." By Prof. J. GOSSELET. (Paris, 1876.)

THIS little book of not quite 200 pages is expressly written for the use of beginners, but self-teaching by its aid is not contemplated, the knowledge which it imparts being intended to be supplemented by the Professors in the French *Lycées*. This the author explains in his Preface, in which he notes the difficulty (greater in France than in England) of giving public-school boys instruction in out-door geology. Fortunately for his pupils, Prof. Gosselet is himself an enthusiastic field geologist, and we are not surprised to see that he very justly compares the necessity for field-work in learning geology to that of laboratory-work as regards chemistry.

In order to give learners an idea of succession in time, the writer compares the geological divisions to the *reigns* in which historical time is divided (especially in school-books). Thus the Carboniferous system is called "*Règne des Productus*," the Cretaceous is headed "*Règne des Rudistes*," and so on. This method will probably be of considerable help in reminding young students of some of the more strongly characteristic fossil groups, and Prof. Gosselet claims no more than this in its favour. There are 166 figures in the text, of these those representing fossils (mostly from d'Orbigny's works, etc.) are very good, whilst the others, although well chosen and instructive, are as a rule very inferior, having probably been spoiled in the engraving.

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[1] "Die fossile Fauna der Silurischen Diluvial-Geschiebe von Sadewitz bei Oels in Nieder-Schlesien." *By Dr. Ferd. Roemer.* 4to. Breslau, 1861.

The style of the Lille Professor is extremely clear, and entirely free as it is from any attempt at so-called "popular" writing, it is yet decidedly interesting. There is an absence of theorizing which one is not accustomed to find in foreign manuals of geology. The book is in fact a collection of carefully selected facts, the inferences drawn from which are striking and obvious. Those parts of geological science which still belong to the region of speculation are omitted, and the student is only told what is known and how it is known. Cataclysms, Pentagonal systems, and all the other horrors of so many French text-books, find no place in this one.

In two instances only, we believe, does the author depart from the well-established views which there is no risk of the student finding contradicted in larger works. One is in the use of the term "Paléontonique." Under this unusual name are grouped the Silurian, Devonian, and Carboniferous rocks, the pre-Cambrian rocks being denominated "Azoic," notwithstanding *Eozoon*, which is mentioned as "ce prétendu fossile," and the Cambrian being regarded merely as the base of the Silurian. The other case is the division of the Carboniferous into three stages, viz.: 1°. The Lower or Carboniferous Limestone. 2°. The Middle, or Coal-Measures. 3°. The Upper, or Permian. Now there is, of course, very much to be said in favour of this grouping, and it is quite possible that a continuation of researches, such as those of Dawson in North America, and Ludwig in Russia, may bring us some day to accept this as the normal and typical state of things, yet it seems scarcely wise or in keeping with the admirable reserve which marks the rest of the book, to include an innovation in which there is so much room for criticism.

Naturally the text-book refers chiefly to French Geology, and its value is much enhanced by the two coloured folding plates which it contains, one being an excellent little geological map of France in eight divisions, and the other consisting of three sections illustrating the rock-structure of the country between the Vosges and Paris, Paris and Laon, and Brussels and Mézières.

On the whole the book will compare favourably with the best of our geological primers and introductory text-books, and leaves most of the foreign works of the kind far behind. G. A. L.

IV.—THE PUZZLE OF LIFE AND HOW IT HAS BEEN PUT TOGETHER. A SHORT HISTORY OF VEGETABLE AND ANIMAL LIFE UPON THE EARTH FROM THE EARLIEST TIMES, INCLUDING AN ACCOUNT OF PRE-HISTORIC MAN, HIS WEAPONS, TOOLS, AND WORKS. By ARTHUR NICOLS. pp. 148. (London, Longmans & Co., 1877.)

ANY attempt to put the leading facts of a science within the comprehension of children, and of grown-up persons whose education has not fitted them to grapple with technical terms, must be fraught with considerable difficulty. Science, as often observed, has a language of its own, and it is frequently impossible to translate it in so simple a form, that all who read may understand. The present little work, however, which is specially addressed to children, is written in so pleasant and easy a style, and its descriptions of life on the earth are on the whole so simple and accurate that we can heartily recommend it to the attention of those who seek such a guide. The illustrations are good and the general appearance of the book such that it may compare most favourably with other primers of geology. H. B. W.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.—November 22nd, 1876.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Pre-Cambrian (or Dimetian) Rocks of St. David's." By Henry Hicks, Esq., F.G.S.

Referring to the ridge of pre-Cambrian rocks, which he described n a former paper as running down the St. David's promontory, and s previously supposed to consist of intrusive syenite and felstone, he author stated that he had now found it to be composed exclusively f altered sedimentary rocks of earlier date than the Cambrian deosits, the conglomerates at the base of which are chiefly made up f pebbles derived from these rocks. Recent investigations had led im to the conclusion that the main ridge was composed of two istinct and decidedly unconformable formations, the older of which omposed of quartzites and altered shales and limestones, contituting the centre of the ridge, has a N.W. and S.E. strike, and ips at a very high angle; whilst the newer series, consisting of ltered shales, and having at its base a conglomerate composed of ebbles of the older rock, has a strike nearly at right angles to that f the latter. For the former he proposed the name of Dimetian, and or the latter that of Pebidian. The author indicated the points of esemblance between these pre-Cambrian Rocks and the Laurentian f Canada, the Malvern Rocks, and others in Scotland and elsehere, but thought it safer at present to abstain from attempting ny definite correlation of them. The exposure of the older, or Dimetian, series led the author to ascribe to those rocks a thickness f at least 15,000 feet; the upper or Pebidian rocks, which flank both ides of the old ridge through a great portion of its length, are pparently of considerably less thickness, but they are in most parts more or less concealed by Cambrian deposits overlying them unconformably. Running nearly parallel with Ramsay Sound is another large mass of the author's Pebidian rocks, and at the south-western extremity of Ramsay Island they compose a bold hill almost 400 feet high, and on the east side of this a fault, with a downthrow of at least 14,000 feet, has brought up the Arenig beds into contact with the pre-Cambrian rocks.

2. "On the Fossil Vertebrates of Spain." By Prof. Salvador Calderon. Communicated by the President.

This paper contained a few introductory observations on the study of the fossil vertebrates of Spain, followed by a classified list of the species (68 in number) which have been recognized in that country. The author particularly remarked on the occurrence of *Sivatherium* and *Hyænarctos* in Spain, on the finding of remains of the Mammoth in that country, and on the presence in the peninsula at a late period of *Bos primigenius*. The earliest known Spanish vertebrates have been obtained from the Carboniferous formation.

December 6th, 1876.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.

The President announced the sad loss the Society had sustained in the death of Mr. David Forbes, F.R.S., one of its Secretaries, which took place on the morning of Tuesday, December 5th. He thought it would be felt by all present that, as a mark of respect to the memory of one so highly esteemed, the proceedings of the Meeting should be limited to the absolutely necessary business; but as one of the authors of a paper on the list had travelled a long distance in order to attend the Meeting, it would hardly be fair to let him go back with the purpose of his journey unaccomplished. He therefore suggested that, in addition to the ordinary formal business of the Meeting, the memoir of MM. Topley and Lebour on the Whin Sill of Northumberland should be read, and that the Meeting should then adjourn.

The following communication was read:

"On the Intrusive Character of the Whin Sill of Northumberland." By W. Topley, F.G.S., Assoc. Inst. C.E., Geological Survey of England and Wales, and G. A. Lebour, F.G.S., Lecturer on Geological Surveying at the University of Durham College of Science, Newcastle-on-Tyne.

The Carboniferous Limestone series of the north of England contains a bed (or beds) of basalt, known as the "Whin Sill," regarding the nature of which opinion has long been divided. Some writers regard it as truly interbedded and contemporaneous; others look upon it as intrusive, and as having been forced laterally between the planes of bedding. The latter opinion is that held by the authors, who stated that through South and Mid-Northumberland there can be no doubt as to the intrusive character of the Whin Sill. This conclusion can be established by the line of outcrop of the trap, and also by the evidence of individual sections.

A review of the literature on the subject was given by the hors, showing that the opinions of geologists are very much ided as to the nature of the Whin Sill. But amongst the prac- l miners of the north of England there are very few who will nit any doubt that the Whin lies evenly, and at one constant izon, amongst the strata. Clear cases to the contrary are looked n as merely local variations, possibly due to successive eruptions submarine lava. The Whin Sill serves them as a definite line, l the limestone next above it is always called the "Tyne Bottom nestone." The question is thus of considerable economic im- tance. It is also of interest in reference to the volcanic history Britain and to classification.

Prof. Phillips took the Whin Sill as the base of the Yoredale ies; the Great Limestone he regarded as its top. But the work the Geological Survey has shown that the Whin Sill lies at dif- ent horizons in different places; sometimes it even lies above the eat Limestone itself. In other words, *the Whin Sill, which is posed to mark the base of the Yoredale Series, sometimes lies above limestone which forms the top of that series.*

With the disappearance of the supposed base-line of the Yoredales s also any good reason for drawing a line here at all. The so- led "Tyne Bottom Limestone" cannot be traced definitely through rthumberland, and the beds above and below this horizon have same general character.

The authors traced the Whin Sill through Northumberland, as far rth as Dunstanborough Castle, showing the varying positions at ich it occurs in the Limestone series, and noting points of erest in some of the sections. The Whin shifts its position ongst the strata to the extent of 1000 feet or more. It fre- ently comes up in bosses through the bedded rocks, and bakes the ls above it quite as much as those below, especially when those ls consist of shale.

As to the age of the Whin Sill, nothing definite can be said. It frequently thrown by faults and lodes. There is no certain case its being unaffected by faults which throw the neighbouring ks, although there are a few doubtful cases which seem to point this direction. As the Whin Sill does not approach the Permian a of Durham, the fact that some of the faults there are believed be pre-Permian cannot be applied as a test of age in this case.

In other districts in Britain in which intrusive basaltic sheets ur amongst the Carboniferous rocks, there is good reason to ieve that in most cases they are pre-Permian, or at least pre- iassic. Whether or not this be the case with the Whin Sill nnot be determined. No light is thrown on this question by the nposition of the rock. Mr. Allport has shown that it resembles, all essential characters, the basalts of other Carboniferous districts, ne of which are possibly contemporaneous, some certainly in- sive.

CORRESPONDENCE.

THE THREEFOLD DIVISION OF THE BOULDER-CLAY OF THE NORTH-WEST OF ENGLAND.

SIR,—Your correspondents Mr. Mackintosh and Mr. Morton raise a much wider question than the one immediately contained in their letters, and it is impossible for me to really discuss the nature of the North Dock Sections without inquiring into the foundations of the theory upon which their classification of these deposits rests. Having in a former letter expressed an opinion that there is not sufficient evidence to justify in this case the threefold division of the Boulder-clay, will you permit me to state more fully my views on the subject.

First then it will be necessary to inquire by what characters a geological subdivision is usually recognized,—there are three:

1st. By the distinctive character of the inclosed fossils.

2nd. By persistent lithological character and continuity over a considerable area.

3rd. By constant relation to well-defined and known deposits above and below.

It is evident that these involve the prevalence of physical conditions differing when each deposit was laid down. These conditions may have differed widely and extended over great areas, or may have been of a more restricted and local nature. Mr. Morton in his communication, it is true, does not commit himself directly to any theory on the subject, but his position involves it all the same.

Upper contains large striated boulders; but the Lower, it is admitted, may possibly also contain large boulders, as it has not been excavated to any considerable depth. The most distinctive feature is that they are divided in places by a bed of sand and well-worn gravel. Mr. Mackintosh considers that these gravels were washed out of a pre-existing glacial clay, of which only hummocky patches remain[1] (Lower Boulder-clay), and their striæ effaced during an inter-glacial period, when the transportation of striated stones had ceased. Without discussing in detail the accuracy of Mr. Morton's description, which I submit does not produce a faithful impression of what actually exists, but rather records what exists in his own mind on the subject, I ask, is the foregoing evidence full enough, or of a nature to justify a careful geologist in accepting an interpretation of the Boulder-clay fraught with such tremendous consequences? For my part, candidly I think it is not, and until some upholder of the theory shows that the Lower Boulder-clay is either a subaerial deposit or contains fossils differing from those in the bed above, or offers any of the distinctive characteristics and continuity such as I have stated are necessary to constitute a geological subdivision, I cannot consider the evidence to be worth much. Looking at the question in a broad aspect, it also appears to me that any division founded as this primarily is on the separation of the Clay by sand and gravel involves, if applied over a wide area, a physical absurdity. Under what possible conditions could a period intervening between the deposition of two beds of clay be represented everywhere only by sands and gravels? If these were washed out of the pre-existing clay, as Mr. Mackintosh infers, what became of the much greater bulk of the clay in which they were imbedded? Where are the equivalent deposits of clay which would surely have representatives somewhere in the interglacial period?

So far as my experience goes, the marine Boulder-clay and sands of the lower plains—and none but marine beds have hitherto presented themselves to me—are from the base of red sand or rock on which they rest to the surface, but one great deposit containing local variations of such a puzzling character as to be interpreted differently by every observer, the supporters of the tripartite division being frequently quite at a loss as to which division the respective beds should be allocated.

T. MELLARD READE.

BLUNDELLSANDS, LIVERPOOL.
Nov. 9th, 1876.

ON THE FORMATION OF GROUND ICE.[2]

SIR,—Relative to the formation of "Ground Ice," I have to offer the following theory. In order that this phenomenon may take place the water must be near the freezing-point. Then we have an analogous condition of things to that of the atmosphere when hoar frost is deposited upon the ground, trees and shrubs on account of these objects radiating their heat more rapidly than the surrounding air, and because they are solid forms presented to a liquid at the moment of crystallization, the feathers of the hoar frost extending to windward as each particle of water is driven by the breeze and frozen upon it.

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[1] From Mr. Morton's description one would infer this deposit extended all over the dock.

[2] See Dr. Landor's paper on "Ground Ice," GEOL. MAG., 1876, Decade II., Vol. III. p. 459.

So in a stream of water at the freezing-point, the stones at the bottom no doubt radiate their heat more rapidly than the surrounding medium, and particle after particle of water assumes its crystalline form on coming in contact with the solid, thus forming tubular masses in the direction of the stream.

124, WINCHEAP, CANTERBURY. S. GORDON MCDAKIN.

PROF. NORDENSKIÖLD ON RECURRENT GLACIAL PERIODS.

SIR,—Prof. Judd has told us repeatedly of late, not without some flourish of trumpets, how completely Prof. Nordenskiöld has demolished Mr. Croll and his theory of the causes of glacial epochs. Now from my youth up I have been backward in my reading, and have had an unconquerable aversion to books, and never read anything myself, if I can get a kind friend to read it for me, and tell me what it is about. So I have not yet read Prof Nordenskiöld;[1] Prof. Judd is evidently thoroughly well up in him, and he would be doing a great kindness to myself, and perhaps others who are equally ignorant and lazy, if he would send you a short article giving Prof. Nordenskiöld's facts and arguments. Prof. Judd says these do not support Mr. Croll's theories; but what I especially want to know is, whether there is anything in them that tells against the generally received views on the subject occupy not unlike grounds. Mr. Bonney admits some tarns, like smere, as glacial; admits, hesitatingly, in part if not wholly, ie lakelets, (do these include Grasmere's neighbours?); admits t once a basin is formed, a glacier works in it "under very ourable conditions" (Letter to Mr. Fisher, p. 377), thus granting he process *increasingly* favourable conditions; but demurs to the ement "that though competent to deepen a lake-basin, a glacier ld originate it." It would thus seem to be with Mr. Bonney uestion, not of ability, but of *time*." Did the glacial period last g enough to enlarge, under "very favourable conditions," a tarn vas able to originate under *less* favourable conditions.

If I understand Mr. Bonney correctly, we are at one both in our ire to bring each case to the test of observation, and in our ap- ciation of the increase of theoretical probability as the series rances from tarn to lake. But if the utmost that even his careful ervations can do for him is to render the glacial theory probable improbable (p. 376), then surely these theoretical probabilities worthy of greater weight than he gives them. His illustrations of wn sand eroding (must we say *tarns*?), and Homeric youths spread- erratics, seem to me scarcely relevant to the state of the question.

The latter paragraphs of Mr. Bonney's letter call for no remark m me, as they involve—at this stage—a knowledge of the Alpine es that I do not possess. I may assure Mr. Bonney, however, t though I have ventured to remark on his theories, I do not estion his facts.

The letter of my friend Mr. Judd I must attempt—with much idence in my own powers—to answer, for it involves destruction my position. First, let me say a word of explanation. In sup- ing me prepared "to admit the overwhelming probabilities" of subsidence theory in regard to all the larger lakes, Mr. Judd sunderstands me. *A priori* probabilities in relation to lakes both ge and small, I believe must be conceded to *both* theories. But in h questions, *overwhelming* probability can be allowed only to rwhelming proof.

In the second place, as regards the halting-place that Mr. Judd ls between tarns and lakes. If, as I argued, a glacier is a tool t greatly grows in calibre and efficiency as a tarn-hollow en- ges,—that scrapes harder and scores deeper, then to concede ns to the feebler tool and deny them enlargement by the more werful, nothing being pointed to as intervening to stop the action, what may very properly be characterized as not logical and not sonable. Nevertheless, as for want of standing room and a crum, Archimedes found his theoretically infinitely powerful tool ited by "reasonable proportions"—the limit of all terrestrial ls, so are "reasonable proportions" the limits also of glaciers and ir work. While caution then compelled me to remember, and to icate in my paper, that there *are* limits to the enlargement of ns by glaciers, that fact—even in Mr. Judd's able hands—leaves tarn and lake question precisely on its former basis.

My friend suggests to me, however, an analogy which may help it on, and aid me to show the fallacy of the analogy by which he seeks to undermine some of the grounds I occupy. Every one who has studied streams and rivers knows that below rapids and falls, and at other places, they scoop pools much deeper, and also broader, than the average stream near the place. The little runnel makes a rough dimple; the Highland burn a linn; the alluvial river leaves in its old channels small meres; and in the valley of the great Amazon these isolated pools are represented by lakelets or lakes some ten miles long, roughly speaking, and thirty or forty feet deep. The rule is, that *the volume of the stream determines the size and the contents by volume of the pools it makes.* Glancing back now to the question of "reasonable proportions," it is evident that this rule must not be unreasonably stretched by a use of blind logic. To say that it applies within reasonable limits, is correct; to say that any one allowing only the pools of the burn to the large river is illogical (as well as *wrong*) is also correct. But to repudiate the rule because it cannot explain lakes proportioned by their size to the hypothetical pools of impossible rivers, would be simply futile.

But I proceed to apply this rule elsewhere. Mr. Judd refuses to allow that a glacier grinds in a basin with added force, on the grounds that "we are led to infer" that streams of water and rivers of ice fall under similar laws of motion (p. 525), and in a preceding paragraph (p. 524) he says what must involve belief on his part, in the production by glaciers of basins proportional in superficies to the pools of the Highland burn and Mississippi river. The above rule, that streams of water make their pools according to their volume, being correct, rivers of ice, Mr. Judd will probably admit, should do likewise. Now streams very much broader than the Amazon do not, and probably could not exist, though I am safe in saying that if they did their pools would be *lakes.* But it is a truism now-a-days that glaciers many times wider than the Amazon did and do exist. The Humboldt glacier is about 60 miles wide; ancient glaciers moved over plateaux and over-rode watersheds, and by the analogy claimed by Mr. Judd we would be justified—nay, encouraged—in predicating as possible lakes limited in breadth only by the volume of glacier and ice-sheet. It is not immoderate then to ask for the sprinkling of tarns and lakes which the nature of the pre-glacial surfaces favoured.

Although, as I think, legitimately damaging to Mr. Judd's position, his parallel between ice and water cannot strictly be carried out. The cascade of a Highland burn tumbles into a pool less broad sometimes than deep, and not much longer. To accredit glaciers with such powers were to forget an important element of difference—the greater rigidity of ice. It is this property—the same that makes glaciers habitually scratch rocks as well as smoothing them, thus giving them a greater rock-hollowing power—that has made it possible for me to argue, what could not be argued of water, that the deeper a glacier drives a basin, "the more fully it feels its power and the more easily and rapidly it works."

A word now upon the stratigraphical division of the question. With deference to Mr. Judd's authority, I must say that I cannot *agree with him that* the horizontality of the Assynt mountains is "an optical delusion." If the boundary-lines of beds 15 and 20 feet thick can be distinguished separately, local deflections from the horizontal even to that amount should be visible too. Nor is the fact that they are only "nearly horizontal" worthy of any weight. Their dip is about 1° westward. They have been spoken of[1] as "with their strata so little inclined that these can be traced by the eye in long horizontal bars on the side of the steeper declivities." But while holding by what I have affirmed on the subject, I am sensible that Mr. Judd's objections can be obviated only by an authority equal to his own.

WARK-ON-TYNE, *Nov. 14th.* HUGH MILLER.

"THE CLIMATE CONTROVERSY."

SIR,—Will you allow me to call the attention of geologists interested in this subject to a statement made by Sir George Nares to the Geographical Society.

He tells us that in the extreme north of Greenland, as well as on the opposite side of Smith's Sound, instead of the land being enveloped in ice like the more southern parts of Greenland, *the glaciers do not reach the sea.* This Sir George attributes to the snowfall being less than the summer sun can dissolve, the snow-bearing clouds discharging their contents principally in latitudes further south, and the land-ice being made up of undissolved snow.

Now does not this militate against the possibility of a polar ice-cap, as well as against the alleged cumulative tendency of snow and ice over any large portion of the polar areas? If with the present lower excentricity the aphelion sun of the northern summer is sufficient to dissolve the winter snow in latitude 82°, would not the perihelion sun of a high excentricity be proportionately more effective, instead, as Mr. Croll contends, of being insufficient to prevent the accumulation of snow? During the augmented cold of the Glacial period would not the region of excessive snowfall have been pushed down to about lat. 55° in Europe (where we find evidences of the enveloping land-ice), and the chief part of Greenland, instead of, as now, being enveloped in ice, have been in the ice-free condition of the land about Smith's Sound? And since the cold of that region, notwithstanding this absence of land-ice, was found to be more intense than that of latitudes where the ice envelopes the land, may not the cold of the Glacial period have been proportionately more intense without any greater snow accumulation than now prevails?

SEARLES V. WOOD, JUN.

OBITUARY.

ELKANAH BILLINGS, F.G.S.

BORN 1820, DIED 1876. AGED 56 YEARS.

THE late Mr. Billings was born in the Township of Gloucester, near Ottawa, Ontario, on the 5th of May, 1820. His family came originally from Wales, and settled in the New England States, but subsequently removed *to Canada.* Mr. Billings was educated partly at Ottawa and partly at Potsdam, in the State of New York. Entering the Law Society of Upper Canada as a student in 1840, he was called to the Bar in 1845. He practised first in the town of Renfrew, and afterwards in Ottawa, or Bytown as it was then called. While residing in the latter place he seems to have found the study of nature more congenial to his tastes than the formalities of the Courts; but whether this was the case or not, it is certain that he commenced to devote much of his time to collecting the organic remains of the Silurian rocks of the neighbourhood, and amassed in particular a fine and almost unique series of Cystideans and Crinoids, which he ultimately presented to the Museum of the Geological Survey.

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[1] *Prof. Geikie's Scenery* of Scotland, p. 211.

His earliest contributions to the literature of science were a few letters on geological subjects which appeared in the Ottawa *Citizen*, but the first palæontological papers of any consequence from his pen were a couple of articles "On some new genera and species of Cystidea from the Trenton Limestone," which were published in the Journal of the Canadian Institute of Toronto for 1854.

In 1856 Mr. Billings commenced the publication of the "Canadian Naturalist and Geologist" as a monthly magazine, of which he was both editor and proprietor. Out of a total of 63 papers in the first volume of the new venture, 55 were either written or compiled by him. Since 1857 the "Naturalist" has been edited by a Committee of the Natural History Society of Montreal, but Mr. Billings was always an active member of this Committee, and there is scarcely a volume of the journal to which he did not contribute.

The merit of Mr. Billings' descriptions of fossils and his zeal in their study did not escape the notice of Canada's veteran geologist, the late Sir W. E. Logan. Accordingly, in 1856, Sir William offered Mr. Billings the position of Palæontologist to the Geological Survey of Canada, an appointment which was at once accepted. In the same year Mr. Billings removed to Montreal, the head-quarters of the Survey, and entered on the discharge of his new duties, which he continued to perform with equal credit to himself and advantage to the country up to the time of his death.

His principal memoirs during his twenty years of office are an illustrated monograph on the Lower Silurian Cystidea and Asteriadæ, also another on the Crinoidea of the same formation, which together form Decades Nos. 3 and 4 of "Canadian Organic Remains:" the palæontological determinations in the "Geology of Canada" for 1863: "Palæozoic Fossils," vol. i., with 426 pages and 401 woodcuts, published at Montreal in 1865: Part 2 of the second volume of ditto, issued in 1874: and "Catalogues of the Silurian Fossils of the Island of Anticosti," Montreal, 1866. He wrote numerous palæontological papers, not only for the "Canadian Naturalist," but also for the American Journal of Science and Arts, and for these pages.

Mr. Billings was for many years one of the Vice-Presidents of the Natural History Society of Montreal, was elected a Member of the Canadian Institute of Toronto in January, 1854, and a Fellow of the Geological Society of London in 1858.

In 1862 he was awarded a bronze medal in Class 1 by the jurors

of the International Exhibition of London, and a similar one at the Exposition Universelle of Paris in 1867. In the latter year, also, he was presented with the silver medal of the Natural History Society of Montreal as a mark of its appreciation of his "long-continued and successful labours in Canadian Science."

As a diversion from his almost unremitting palæontological researches, Mr. Billings, at different periods of his life, occupied himself with the study of mineralogy and entomology. Among insects, his favourite group was the Coleoptera, and he made quite an extensive collection of Canadian beetles, which a few years since he deposited in the Museum of the Natural History Society of Montreal.

Like many other original thinkers, Mr. Billings was entirely self-taught, so far as science was concerned, and those who were best qualified to form an opinion on both points knew not which to admire most, the untiring industry of the man, or the conscientious thoroughness of his work. To show that he spared no pains to increase his knowledge of the science which he made peculiarly his own, it may be mentioned that he learned to translate with ease, palæontological essays, written not only in the French and German, but also in the Norwegian, Swedish, and Danish languages.

J. F. WHITEAVES.

DAVID FORBES, F.R.S., SEC. G.S., F.C.S., ETC.

BORN 6 SEPT. 1828. DIED 5 DEC. 1876. AGED 48 YEARS.

FOR many years past the names of its oldest and most eminent members have one by one been removed from the list of the Geological Society, and we have looked around, almost in despair, for men to fill the front benches, once distinguished by the presence of a Murchison, a Lyell, a Scrope, a Sedgwick, or a Phillips. Now, alas! we have to record with sorrow the loss of one of those younger members from whom we had fondly looked for some ten years at least of active scientific work.

The name of Forbes had already become well-known and honoured in association with the Geological and other learned Societies by the scientific labours of the late Prof. Edward Forbes, brother of the subject of our present memoir; and when David Forbes returned to England after nearly twenty years of his life had been spent abroad in Norway and South America, he was cordially welcomed as a fellow-worker by his brother Geologists and speedily took an honoured place among them.

Born in the Isle of Man in 1828, he was partly educated there and subsequently at Brentwood in Essex. His school-days over, he was removed to the University of Edinburgh, where, in Dr. Wilson's laboratory, he laid the foundation for those chemical and physical studies which so distinguished his later years.

An early opportunity was afforded him of turning this chemical and scientific training to good account, and before he was 20 he accompanied Mr. Brooke Evans to explore the mineral resources and afterwards to superintend extensive mining and metallurgical works at Espedal in Norway, a post which he held for about 12 years. During this period he travelled much, and lost no opportunity of increasing his store of scientific knowledge, as his writings testify. David Forbes was a man of resolute and determined courage, and when in Norway, in 1848, and a revolutionary movement threatened the country, he armed 400 of his men to aid the Government. For this service the King sent for Forbes, and thanked him personally, and ever afterwards remained his friend.

During this time he became a partner in the well-known firm of Evans and Askin, Nickel-smelters, Birmingham, and it was in connexion with them that he visited Chile, Peru and Bolivia, in search of Nickel and Cobalt. His investigations into the mineral resources of these countries extended over six years. During the years 1857–60, he made a special geological exploration of certain districts in South America, the result of which, entitled "On the Geology of Bolivia and Southern Peru," was communicated to the Geological Society in 1860.

The paper is full of interesting details, and although many points may appear to have been neglected, this is not the result of oversight, but, as the author truly observes, is "due to the great difficulties and frequently severe privations encountered in exploring a country in many parts entirely uninhabited, or to a great extent in a savage condition, and, further, by having been limited both as to time and pecuniary resources, and hampered by other occupations and by the political state of the country."

A second communication was to have embodied the Geology and Mineralogy of the neighbouring Republic of Chile and the Argentine Provinces, which would have strengthened his previous conclusions, especially as several of the geological formations not well developed or studied in the districts described in his first paper, were seen by Forbes much better and more characteristically exhibited further south. From South America he made an expedition to the South Sea Islands, and spent some time in studying their volcanic formations and minerals.

During four years he traversed Chile in all directions from considerably south of Santiago northwards, up to the frontiers of Bolivia in the Desert of Atacama.

He inspected all the principal and some of the lesser mining districts along the range of the Cordilleras; from these he collected a valuable and extensive series of minerals, including about 190 species, of which he published a list (much more copious than that given in the second edition of Domeyko's Mineralogy), together with a classification, according to the mode of their geological occurrence, in his paper "On the Mineralogy of Chile" (see Phil. Mag., 1865).

It was with the same view that during his long residence in Norway Forbes studied the Mineralogy of the several districts in that country, viz. with especial reference to the circumstances under which each mineral occurred and the causes which led to its appearance. (See the Edinb. Phil. Journ., 1856–57, and Quart. Journ. Geol. Soc. Lond., 1855.)

His cabinets are replete with abundant and carefully selected rocks and minerals, all intended to illustrate the association, paragenesis and mode of occurrence of minerals in connexion with the origin and formation of the rock-masses or mineral veins in which they are found imbedded.

On his return from Bolivia in 1860, he was requested, previous to his departure, by a Committee representing the chief commercial and mining interests of that country, to address a letter to Lord John Russell urging the re-appointment of a representative of the British Government to protect British interests. This letter was accompanied by a memorandum on the resources of the Republic. Although the official appointment was not then deemed necessary, it must have been some satisfaction to Mr. David Forbes to know that a number of influential persons connected with mining enterprises requested Sir Roderick Murchison to use his influence to secure the appointment of Mr. David Forbes to the vacant post in that country.

Igneous and Metamorphic phenomena and the resulting changes in rock-formations were among David Forbes's especial and favourite studies, and he lost no opportunity, during his extensive travels in Europe and Africa, but especially in Mexico and South America, of observing the effects of modern volcanic action, and their relation to similar phenomena in past time.

Having ample opportunities in Norway, in connexion with metallurgical operations, he was enabled to submit various rocks to very high temperatures and pressures for longer or shorter periods, and thus imitate metamorphic action in the production of various forms of rock-structures. The results of these experiments were partly embodied in his paper to the Geological Society in 1855, "On the Causes producing Foliation in Rocks." Bearing also on this subject are his papers "On the Chemical Composition of some Minerals from the South of Norway" (Brit. Assoc. Rep., 1854. Edinb. New Phil. Journ., 1855–57), "On the Igneous Rocks of Staffordshire" (GEOL. MAG. Vol. III. p. 23) and "On the Contraction of Igneous Rocks in Cooling" (GEOL. MAG. Vol. VII. p. 1).

Mr. Forbes was a Fellow of the Royal, the Chemical, and the Geological Societies. Of the latter he had been the active Honorary Secretary for some years past. As Foreign Secretary of the Iron and Steel Institute, he has prepared for six years (1871–76) careful and elaborate details of the progress of the iron and steel industries in foreign countries, in which his knowledge of languages materially assisted him. Nor did geological science and mineralogy alone interest him, for as a member of the Ethnological Society he contributed an interesting and elaborate paper "On the Aymara Indians of Bolivia and Peru."

Upwards of fifty papers have been communicated by Mr. David Forbes to the Scientific Societies and Journals, besides a long series of articles in the "Chemical News," the Transactions of the "Iron and Steel Institute." *Sixteen of* Mr. Forbes's articles and letters have appeared in the GEOLOGICAL MAGAZINE from 1866—1872. They all indicate the tendency of his mind to study the bearings of chemistry on igneous and cosmical phenomena. Forbes felt that whilst in other departments of Geology, Great Britain was foremost, she was far behind in the study of Chemical Geology, and he hoped that others might be induced to devote themselves to this most interesting and prolific branch of scientific inquiry. His views were expressed in his paper on "Chemical Geology" (*Chemical News*, 1867' and 1868; *Popular Science Review*, 1868; GEOL. MAG., 1868, Vol. V. p. 366, and in his Lecture to the Chemical Society, 1868), and also in his paper on the "Chemistry of the Primeval Earth," (GEOL. MAG.. 1867, Vol. IV. p. 433; and 1868, Vol. V., p. 105), in which he criticized certain opinions of Dr. Sterry Hunt published in his lecture at the Royal Institution (1867) on the same subject (GEOL. MAG. 1867, Vol. IV. p. 357).

His most important papers are *already quoted* in the body of this memoir, to which may be added the following:—

"On the Relation of the Silurian and Metamorphic Rocks of the South of Norway.' Edinb. New Phil. Journ. 1856, iii. p. 79.
"On the Causes producing Foliation in Rocks." Quart. Journ. Geol. Soc. 1855, xl. p. 166.
"On the So-called Primitive Formation of the South Coast of Norway." Quart. Journ. Geol. Soc., 1858, xiv.
"On the Geology of South America." Quart. Journ. Geol. Soc. 1860.
"On the application of the Blowpipe to the Quantitative Determination of certain Minerals"—a series of papers in the "Chemical News."
"Researches in British Mineralogy." Phil. Mag., 1867 and 1868.

Mr. Forbes devoted himself almost entirely to his professional and literary pursuits, and took but little physical exercise, and it is to be feared that his too sedentary habits, together with the sad domestic loss he had recently suffered, depressed his spirits and broke up a constitution already to some extent enfeebled by recurrent fever caught in South America, and so accelerated his end.

His loss is keenly felt by those friends who really knew his genial and social character; whilst his scientific associates, who had hoped for the further prosecution and publication of his researches and observations on rocks and minerals will all regret his vacant place in their midst.

Removed from us at so early a period in his career, when his future promised a devotion to his favourite studies and the arrangement of the scientific notes he had so earnestly collected, some of which it is hoped may still be rendered available. although we fear, with regard to a large proportion, the mind of the master whose hand penned them could alone render them useful for scientific purposes. Endowed with great mental activity, although partly impaired of late by the state of his health, he seems to have acted on the motto of the great Swedish naturalist—

"NULLA DIES SINE LINEA."

J. M.

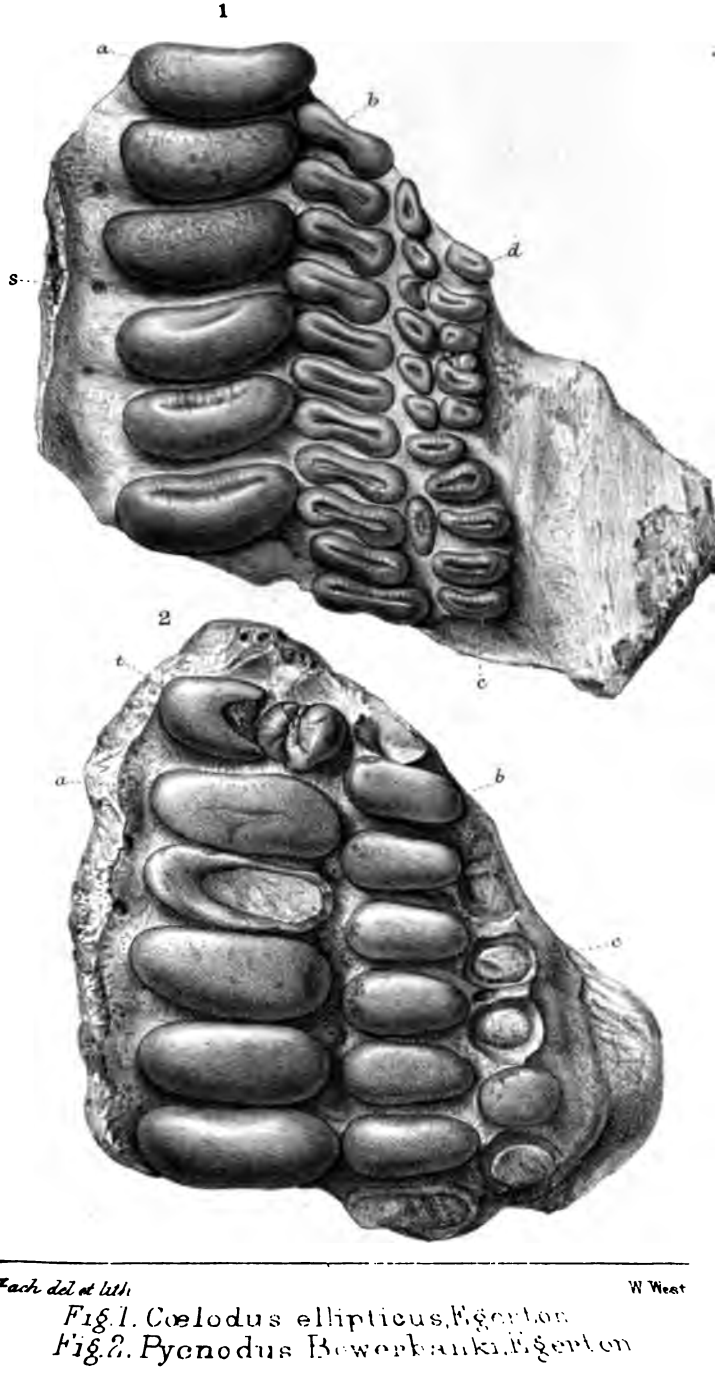

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Fig. 1. Cœlodus ellipticus, Egerton.
Fig. 2. Pycnodus Bowerbankii, Egerton.

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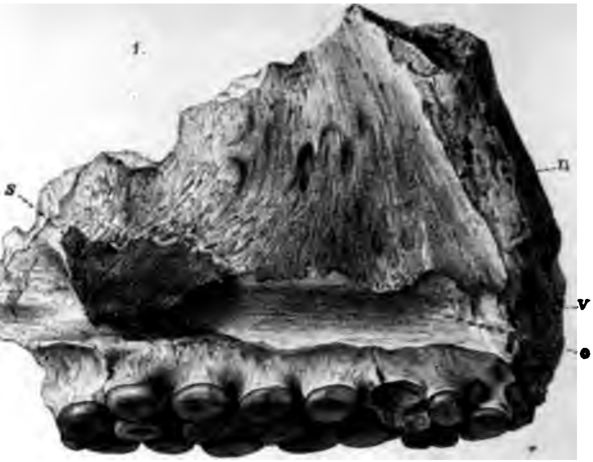

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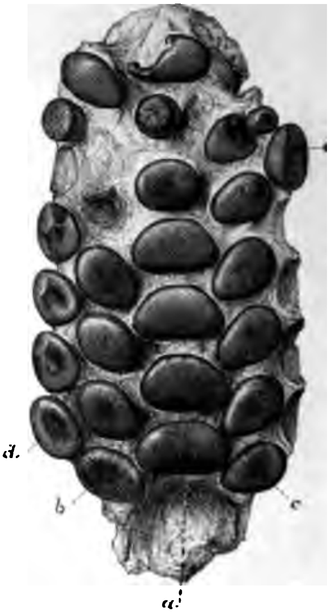

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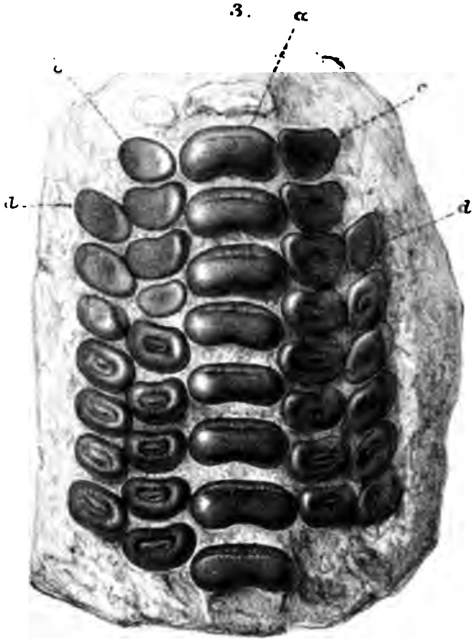

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Fig.^s 1 & 2. Pycnodus pachyrhinus, Egerton.
Fig. 3 Cœlodus gyrodoides, Egerton.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE II. VOL. IV.
No. II.—FEBRUARY, 1877.

ORIGINAL ARTICLES.

I.—On some New Pycnodonts.

By Sir Philip Grey-Egerton, Bart., M.P., F.R.S., F.G.S.

(PLATES III. and IV.)

1. Cœlodus ellipticus, Egerton. Pl. III. Fig. 1.

Mr. Alfred Craven, who for some months past has been occupied in making a collection of the organic remains found in the Gault at Folkestone, has submitted to me for examination and description (if requisite) a specimen of a Pycnodont jaw which, both for the perfect condition in which it is preserved and for the peculiarity of its characters, is worthy both of description and representation. The specimen is the right mandible with most of the tritoral teeth preserved in their natural position. It betokens a fish of the largest size of the family to which it belongs, rivalling in this respect even the *Pycnodus gigas* of the Jura beds. The symphyseal border (Pl. III. Fig. 1 *s*) measures two inches and eight-tenths of an inch in length, and half an inch in thickness. As the anterior extremity is wanting, the natural size was probably half an inch longer. The outer margin of the jaw measures four inches, and the basal line—connecting the outer and symphyseal elements of the triangle—three inches and two-tenths. The dental armature is composed of four ranks on the anterior and three on the posterior area of the mandible. The inner row (Pl. III. Fig. 1 *a*) consists of teeth very considerably larger than those of the succeeding rows. Six of these are retained; but as the anterior extremity of the bone is broken, there were probably one or two more. The individual teeth measure nine-tenths of an inch by four-tenths. They are elliptic in outline, but slightly crescentic on the anterior margin. The four anterior plates show progressive marks of attrition; but the fifth and sixth, not having as yet come into contact with the vomerine teeth, disclose the peculiar character of the dentition. This consists in the occurrence of a longitudinal sulcus on the anterior face of the tooth, corresponding in form with the outline of the tooth, and bordered by a slightly crenulated margin; the remaining area of the tooth being perfectly smooth. The whole triturating surface is coated with a thick and lustrous enamel. The second rank (Pl. III. Fig. 1 *b*) contains eleven teeth of an elongated elliptic form, constricted at the waist, like an hour-glass. They measure six-tenths of an inch in length. They are so arranged that the alternate teeth are opposite to the intervals between those of the inner or principal *row*. They all have the longitudinal furrow characteristic of the larger teeth, but it occurs in the centre of the denticle, and is deeper in proportion to the size of the tooth, so that it is hardly altogether effaced by use. The four posterior teeth of the third row (Pl. III. Fig. 1 *c*) are smaller than those of the second, and the outline is less elliptic and more irregular. These also have the central furrow described before, but modified in harmony with the form of the teeth. The teeth in front of these (Pl. III. Fig. 1 *d*) are in a double row, and seem to have arisen from divided germs, each pair making up the form and size of one of the posterior teeth, suggesting the idea that the single teeth of the hinder portion of the rank are replaced by twin teeth in the front of the mandible. This peculiarity will be alluded to more particularly hereafter. The result is a great irregularity in this part of the dentition. Some of these small teeth are elliptical, some more or less rounded, some trigonal; some have the larger axis to the front, others coincide with the two inner ranks in having the larger axis transversal. They all, however, have a central pit varying in form with the outline of the tooth. The mandibular bone (Pl. III. Fig. 1 *m*) extends an inch or more backwards beyond the dentigerous area; it is close-grained and solid, and measures an inch in thickness in the middle, and thins off a little towards the symphysis, and more so to form the outer edge of the mouth.

Before attempting to determine to which genus of the Pycnodont family this specimen is referable, it will be necessary to notice some of the discrepancies which occur in the writings of those authors who have treated of this subject with regard to the number of the ranks of mandibular teeth. Agassiz[1] says, "The lower jaw is carpetted with large teeth arranged in *three* or *five* ranks on each side." Pictet[2] follows this dictum. Wagner and Thiolliere,[3] on the contrary, maintain that the correct number is *four;* but in the figure given by the latter of *Pycnodus Bernardi* (pl. 5, fig. 2), five rows are distinctly shown. Sauvage[4] divides the genus into those with four rows and those with more. The great opportunities afforded me of examining these interesting remains of a family entirely extinct since the Miocene age have led me to think that much irregularity obtains in the development of the marginal rows of tritoral teeth, and that these variations are not of specific value except in cases where they are constant. In *Pycnodus Bucklandi, Hugii* and *parvus* there are always *five* and sometimes *six rows.* The inner row when present is invariably composed of small teeth, which are sometimes irregular, sometimes have fallen away through use or age, and in one specimen in my collection are duplicated. The second row is always composed of the largest teeth and is generally constant in character. The third row is also for the most part regular, but composed of much smaller teeth than the second. The outer rows are subject to great irregularities in number, form, and position. In some cases small teeth are intercalated between the rows, in others the larger teeth are replaced by two smaller ones, as in the specimen described in this article; but in every case these teeth are smaller than those of the principal row. In the genus *Gyrodus* the dental formula does not appear to be subject to these irregularities, there being constantly four rows in each mandible, and five in the vomer. In this genus the outer row comes next in size to the principal row, and all the teeth have a central eminence surrounded by a fossa. In *Microdon* also the teeth of the outer row of the four are next in size to the principal ones.

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[1] Poissons Fossiles, vol. 2, pt. 2, page 183.
[2] Traité de Paléontologie, vol. 2, p. 197.
[3] Poissons Fossiles du Bugey, p. 11.
[4] Poissons des Formations Secondaires du Boulonnais.

Palæobalistum of de Blainville has three rows, the component teeth being arranged obliquely. In *Mesodon* of Wagner the teeth are oval, concave, and notched on the periphery. Heckel[1] has added two genera to the family,—*Stemmatodus* having three rows of teeth on either side with notched borders and granulate crowns; and *Cœlodus* described as having three rows on each mandible, elliptical, with a slight depression on the surface of each tooth. He has, moreover, upon the evidence of anatomical structure combined with the dental characters, remodelled the arrangement of the species of this family.

Microdon hexagonus and *rugulosus* of Agassiz are referred to *Gyrodus*, as is also *Microdon truncatus* of Wagner. *Pycnodus Itieri*, *Sauvanasii*, *Bernardi*, *Egertoni*, and *Wagneri* of Thiolliere; *Pycnodus umbonatus* and *Hügii* of Agassiz; and *Pycnodus formosus* and *Reussii* of Wagner, are removed to the genus *Microdon*. *Gyrodus macropterus* of Agassiz, and *Pycnodus liassicus* mihi, are joined to *Mesodon*. *Pycnodus rhombus* of Agassiz goes to *Stemmatodus*, and *Pycnodus orbiculatus* of Agassiz to its pristine genus *Palæobalistum* of de Blainville. The new genus *Cœlodus*, in addition to the many fine species of entire fish found in Austria, is made to include *Pycnodus rhombus*, and *Glossodus angustatus* of Costa and *Pycnodus Mantelli* of Agassiz.

On comparing the Folkestone fossil with these several forms, there is no doubt but that it mostly resembles the genus *Cœlodus* of Heckel. A detached tooth from the outer row might indeed be mistaken for a *Gyrodus* tooth if the crown were at all ground down, but in a young tooth with the surface intact the difference is very discernible. In specimens having the ranks of teeth preserved there can be no mistake, as in *Gyrodus* the teeth of the outer row are next in size to the principal teeth, whereas in *Cœlodus* they diminish progressively from the inner to the outer series. The number of the dental ranks in the hinder part of the jaw agrees with Heckel's formula, and, as I have stated before, I do not consider the irregularity of the subsidiary ranks in the anterior portion as indicative of generic variation. Assuming then that this mandible belongs to *Cœlodus*, it is manifest that it cannot be identified with any of the species of the genus yet described. It is of larger size than the *Cœlodus Saturnus* figured by Heckel, and differs from that and all the other species in having the teeth of the second row more numerous and more elliptical. I propose to call it *Cœlodus ellipticus*.

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[1] *Beiträge zur Kenntniss der fossilen* Fische Oesterreichs, pt. 2.

2. Cœlodus gyrodoides, Egerton. Plate IV. Fig. 3.

The Earl of Enniskillen possesses a fine specimen of a Pycnodont vomer from the Greensand of Pinney Bay, near Lyme Regis, which, although named *Gyrodus new species*, I am inclined to refer to the genus *Cœlodus*. It measures two inches and a half in length by one inch and seven-tenths at the base and one inch four-tenths in front. It carries five rows of tritoral teeth. The central series (Pl. IV. Fig. 3 *a*) is composed of eight reniform teeth, six-tenths of an inch long by two-tenths wide. They have an elongated sulcus on the anterior face of each tooth similar to those which characterize the mandibular teeth of *Cœlodus*. The adjoining rows on either side have nine teeth on the right side (Fig. 3 *b*) and eight on the left (Fig. 3 *c*). They are considerably smaller than those of the centre row and more obtuse. The depression on the grinding surface is larger in proportion to the area of the tooth, and each pit has a slight papilla at the bottom of the cavity. The two outer rows (Fig. 3 *d d*) contain seven teeth in the right and six in the left. These are smaller than those in the adjacent rows and more oval in shape, with a slight truncation of the outer margin. These teeth might be mistaken for those of *Gyrodus*, but on comparing them with perfect specimens of that genus it will be seen that the periphery of the tooth in it is lower than the central boss, and the crenulation of the projecting ridges more distinct, giving a *rosette* character to the crown, whereas in *Cœlodus* the marginal teeth have more the appearance of pustules with a puckered depression in the centre. There can be no hesitation in affirming that sketches of three Pycnodont mandibles which I considered could not all be referred to *Pycnodus toliapicus.* For thirty years the subject escaped my memory, until the examination of the Folkestone specimen described in a previous article reminded me of the occurrence, and induced me to make a comparison between it and the Bowerbankian specimens now in the British Museum. Two of these belong no doubt to *Pycnodus toliapicus.* They are right and left mandibles, and so nearly of a size that they might have belonged to the same individual. The right jaw has three rows of teeth. Those of the inner row are the largest. They are five in number and elliptic in form, agreeing in the latter respect with the description given by Agassiz: "The principal teeth are elongated and rounded at the extremities." The second row contains six teeth very much smaller than those of the inner row, and of ovoid outline; the third row has four teeth of similar figure to the preceding ones, but rather smaller. The left mandible corresponds in these details with the right, but has in addition an inner row of small teeth between the principal row and the symphysis, of which three anterior ones are apparently *in sitú.* The occurrence of this inner row of denticles is not in my opinion of specific signification when the other characters correspond so closely. It is constant in *Gyrodus,* but in *Pycnodus,* as I have before stated, it is by no means a characteristic feature. When it is present the component teeth are invariably smaller than any others. On comparing these specimens and the figure of *Pycnodus toliapicus* given on pl. 72 *a.* fig. 55, of vol. ii. pt. 2, of the Poissons Fossiles, with the figure of *Periodus Kœnigi,* figs. 61–2 on the same plate, and the specimens in the British Museum and my own cabinet, I am at a loss to discover any difference either generic or specific between them. The specimens of *Periodus* have been more rubbed down by use, and the discrepancy in the form of the crowns is due to the unequal attrition of the vomerine teeth.

The third specimen from Dr. Bowerbank's collection is a right mandible in beautiful preservation. It is quite as large as *Cœlodus ellipticus* described above, and contains three rows of teeth. The inner or principal row (Pl. III. Fig. 2 *a*) has five normal teeth in series and a sixth, the anterior one, replaced by what I have designated a twin tooth (Pl. III. Fig. 2 *t*). The regular teeth of this row are larger and more obtusely oval than those of *Pycnodus toliapicus.* The twin tooth is divided into a circular denticle, rather irregular, and a crescentic portion embracing the inner periphery of the former. I have already alluded to this dentary sport as being not uncommon in some of the Pycnodont genera. The second series (Pl. III. Fig. 2 *b*) comprises eight teeth, which, although considerably smaller than the principal grinders, are nevertheless comparatively of larger size than those of *Pycnodus toliapicus.* They are elliptic in form, differing also in this respect from the oval teeth of that species. The outer row (Pl. III. Fig. 2 *c*) contains six teeth very much smaller and nearly circular; the crown or triturating surface of those not yet come into use is irregularly puckered. It will be gathered from these details that the species is well characterized and broadly distinct from any other of the genus. I have named it after i discoverer and former possessor, Dr. Bowerbank, who I am happy know is still able to take his share of scientific work in those branch of research in which he has laboured so hard and done so much.

4. On a Vomerine Plate of a Pycnodus from the London Cl Sheppey. Pl. IV. Figs. 1, 2.

I have long had in my possession a Pycnodont vomer, found the Eocene Clay of the Isle of Sheppey, which first gave me a cl to the anatomical details of the maxillary apparatus in this famil Having been found in clay, the matrix was easily cleared away as to display the entire bone, in so far as it was preserved. T five rows of teeth, forming the roof of the mouth in all the spec of *Pycnodus*, are implanted on the under surface of the vomeri plate, which is fully one inch in width. A solid vertical plate bone (Pl. IV. Fig. 1 *v*) ascends from the upper surface of the von to the height of one inch, where it meets a corresponding descendi plate (Pl. IV. Fig. 1 *n*) of the nasal (Ethmoid) bone, to which it united by suture. The anterior margins of both bones expa transversely so as to form a frontal shield seven-tenths of an in wide, to which the premaxillary bones were attached. This structı has been well described by Thiolliere, who remarks, "L'ethmoide remarquable par l'étendue de la cloison verticale qu'il presente ı dessous du front, et au-dessus du sphénoïde anterieure et du vome The total height of the frontal profile is two inches and a half, l the upper portion of the nasal bone is broken away. The an formed by the frontal line and the palate is sixty-seven degre Although I have stated that the nasal bone is united by suture the vomer, this mode of attachment is confined to the frontal uni Two thin lateral plates of bone expand downwards from the si of the nasal bone and overlap the vomerine walls to within half inch of the dentary platform. The space thus left of the vomer l the appearance of a shallow groove, and this groove (Pl. IV. Fig. 1 at its distal extremity is arched over by a fragment of bone (Pl.] Fig. 1 *s*), probably an anterior process of the presphenoid, formi a large foramen, which in all probability constitutes the olfact duct. The dentigerous platform of the vomer measures two inc and a half long by one inch and four-tenths wide. The med row (Pl. IV. Fig. 2 *a*) counting from behind, has four large o teeth in succession, then comes a smaller circular tooth, succee by a still smaller one, and in front a tooth of the normal form ε size. This affords another and striking instance of the irregula in the tooth development in the Pycnodont family to which I h before referred. The second row on the right side (Pl. IV. Fig. 2 has four teeth in order, the two next wanting, and the front one *situ*. On the left side (Pl. IV. Fig. 2 *c*) there are six teeth, regular. All the teeth in these rows are oval and arranged obliqu

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[1] Thiolliere is inclined to think that the so-called Vomer may be compounde three bones, the Vomer proper carrying the three median rows of teeth, and Palatine or Maxillary bones the outer or marginal rows.—*Poissons Fossiles du Bu* [illegible]. 18.

to the interspaces of the teeth in the median row. The outer row on the right side (Pl. IV. Fig. 2 *d*) has four teeth, one vacancy and an anterior circular tooth, similar to the small circular tooth of the median set. All the teeth on the left side are broken away except the anterior one (Pl. IV. Fig. 2 *e*) and a small irregular tooth, similar though smaller than those in the median and right outer ranks. These teeth are oval on their inner periphery, but truncated along the maxillary border. All the teeth in this specimen which have not been ground down by use have a shallow depression in the centre of each tooth, over which the outer coat or layer of ganoine is spread in minute folds radiating from the centre. This type of tooth, as I have before explained, is easily distinguishable from the dentition of *Gyrodus*.

As there is no instance on record of the occurrence of a Sheppey Pycnodont with the upper and lower masticating apparatus so associated as to render it probable that they were derived from the same individual, it is impossible to determine whether the specimen here described should be assigned to *Pycnodus toliapicus* or to *Pycnodus Bowerbanki*, or to neither. The light thrown upon the subject by the examination of other species in which the dentition is accurately known, leads to the conclusion, that the median vomerine teeth agree in general character with the large mandibular teeth, but are more obtuse in outline. If this be so, this vomer is more nearly related to *Pycnodus toliapicus* than to *Pycnodus Bowerbanki*; at the same time in other respects it so far differs that I must hesitate to consider it as referable to that species. The most striking character of this interesting relic is the extraordinary modification of the facial anatomy for affording power to work the masticating apparatus, and suggests to me the provisional name of *Pycnodus pachyrhinus*.

EXPLANATION OF PLATES III. AND IV.

PLATE III.	FIG. 1.—*Cœlodus ellipticus*,	Egerton.	Right mandible.		
„	FIG. 2.—*Pycnodus Bowerbanki*,	„	Right mandible.		
PLATE IV.	FIG. 1.—*Pycnodus pachyrhinus*,	„	Vomer.	Profile.	
„	FIG. 2.—*Pycnodus pachyrhinus*,	„	Vomer.	From below.	
„	FIG. 3.—*Cœlodus gyrodoides*,	„	Vomer.	From below.	

II.—NOTE ON THE GENUS *ANTHRAPALÆMON* (*PALÆOCARABUS*) OF SALTER, FROM THE COAL-MEASURES.

"THE earliest known example of a fossil Macrourous Decapod Crustacean was obtained by Prof. Prestwich from the Pennystone Ironstone of the Coal-measures, Coalbrook-dale, Shropshire, and was at that time referred by Prof. H. Milne-Edwards, who examined it, to the PHYLLOPODA under the name of *Apus dubius* (see Trans. Geol. Soc. Lond., 1836, 2nd series, vol. v. p. 413). In 1844 some further remains of this genus were noticed by W. Ick, Esq., F.G.S. (see Quart. Journ. Geol. Soc. Lond., vol. i. p. 199). We are indebted to the late Mr. J. W. Salter for the first correct account of these Crustacea in 1861, when he figured the almost entire form from a specimen in the collection of Dr. William Grossart, obtained in the 'slaty blackband' 960 feet below the 'Ell-coal' at Goodhock Hill, Shotts, Lanarkshire. For this form Mr. Salter proposed the genus *Anthrapalæmon* (a name which, as he observes, 'has only a general signification, and is not intended to indicate a real relation to *Palæmon*,' to which genus it has not the least resemblance or affinity). He also added the specific name of *Grossartii*.

"Mr. Salter also proposed for the Coalbrook-dale form (*Apus dubius* of Milne-Edwards) the sub-generic appellation of *Palæocarabus*. This sub-genus was subsequently erected into a genus by the same author, and a new species, described under the specific appellation *Russellianus*, was added."

In a paper communicated to the Glasgow Geological Society,[1] from which the above is an extract, Mr. Woodward has pointed out that the characters upon which Mr. Salter depended for his new genus and species were based on an accidental displacement of the antennules and antennæ.

Mr. Woodward further concludes that there are no good grounds for maintaining two genera on these Crustacean remains from the Ironstone. The carapaces of *A. Grossartii* and *P. Russellianus* agreeing in all particulars. As *Anthrapalæmon* has two years' priority over *Palæocarabus*, Mr. Woodward suggests the retention of the older name.

In their Palæontology of Illinois (1868, vol. iii. p. 554) Messrs. Meek and Worthen have figured and described another example of this type under the name of *Anthrapalæmon gracilis*, which in many respects closely agrees with the Scottish and English forms.

The subjoined note by Principal Dawson, F.R.S., on a new form of *Anthrapalæmon* from Nova Scotia, adds yet another locality to the wide distribution of this Palæozoic type.—EDIT. GEOL. MAG.

III.—NOTE ON TWO PALÆOZOIC CRUSTACEANS FROM NOVA SCOTIA.

By J. W. DAWSON, LL.D., F.R.S., F.G.S.,
Principal of M'Gill's College, Montreal, Canada.

Fig. 1.[2] *Anthrapalæmon* (*Palæocarabus*) *Hilliana*, n.s.

THE specimen referred to in the following note is I believe the first example of a Macrourous Crustacean from the Carboniferous of Nova Scotia; and it is interesting to find, as pointed out to me by Mr. Woodward, that its affinities are so close with the long known *Palæocarabus dubius* of Prestwich, and *Anthrapalæmon* of Salter, from the English and Scottish Coal-measures. It was found by Mr. Albert G. Hill, manager of the Cumberland Coal-mine, at the South Joggins in Nova Scotia, in one of the bands of black bituminous limestone which occur in the middle part of the Coal Formation.

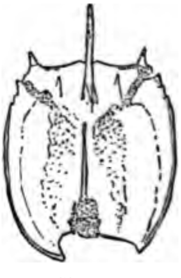

FIG. 1.

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[1] Trans. Glasgow Geol. Soc. 1866, vol. ii. pp. 68–69, pl. iii. figs. 5–7.

[2] Drawn by Mr. G. H. Emerton, and reproduced by 'Dallastint.'

It is associated with shells of *Naiadites carbonarius* and *N. elongatus* (*Anthracomya* of Salter) and with carapaces of *Cythere* and *Bairdia*.

The specimen is a flattened carapace, without any of the other parts. Its length, without the rostrum, is 0·9 inch. The rostrum projects 0·25 inch. The extreme breadth is 0·85 inch. The surface is smooth at the sides, but papillose in the median portion. As compared with the published figures and descriptions of *P. dubius*, its distinctive characters appear to be:—1. The shorter rostrum and larger spines at the anterior angles. 2. The reduction of the dentations on the anterior part of the sides to five in number. 3. The presence of two strong spines in front of the cervical groove at each side of the base of the rostrum, and parallel to it, and rather less than half-way between it and the lateral margins. Whether the dorsal ridge extended to the posterior margin cannot be seen, as this part of the crust is imperfect. In other respects it resembles the British species, and may be merely one of its varietal forms.

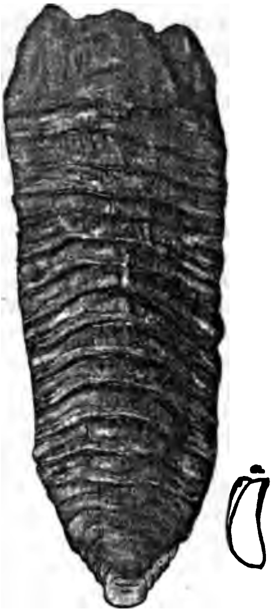

FIG. 2.

Fig. 2.[1] *Homalonotus Dawsoni*, Hall.

This species was described by Prof. Hall in the Canadian Naturalist in 1860, from specimens of the pygidium and portions of the body segments, collected at Arisaig, in Nova Scotia. The cephalic shield was afterwards found at the same place, and was described and figured by Dr. Dawson, in "Acadian Geology," second edition, 1868. The present specimen, showing the entire length of the body, with the exception of a small part of the posterior extremity, was found by Mr. D. Fraser, in the Upper Silurian slates of the East River of Pictou, Nova Scotia.

The specimen is a cast of the inner surface of the crust, so that the deep transverse furrows are not the margins of the segments, but the impressions of their strong internal ridges. The ends of the pleuræ are bent down abruptly at right angles to the back, giving it a very narrow appearance when viewed from above; but this may be partly a result of distortion, in connexion with the slaty cleavage which has affected the rock. Still, from the great width of the segments, the thorax is of great length, in comparison with the cephalic shield and pygidium, and this seems to be one of the distinctive characters of the species. The caudal shield, as described by Prof. Hall, has, in all, nine annulations; of which in this specimen

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[1] From a Photograph by *Henderson*, reproduced by 'Dallastint.'

two, as well as the smooth extremity of the shields, have been broken off. The impression of the external surface, seen on the matrix, shows that the axis of the thoracic segments was marked with scattered tubercles. The cephalic shield and pygidium appear to have been minutely granulate. On a portion of the latter these granulations have a scaly form, as in some other species of the genus. The ends of the pleuræ are broad and rounded. (See Fig. 2 *a*.)

The horizon of the fossil is the upper part of the Arisaig series of Nova Scotia, equivalent to the Lower Helderberg of New York and Pennsylvania, and to the Ludlow of England. The matrix of the specimen contained *Chonetes Nova-Scotica*, Hall; *Megambonia cancellata*, Hall; *Avicula Honeymani*, Hall; *Beyrichia pustulosa*, Hall; and other fossils characteristic of that horizon.

This fine species is evidently a close ally of *H. Knightii* of the English Ludlow, though it differs considerably in details of structure. According to Mr. Salter's determination of some specimens from Arisaig placed in his hands by Dr. Honeyman, *H. Knightii* is also found at that place;[1] but I have not met with any specimens of it. The representative of this species in the Lower Helderberg of New York is *H. Vanuxemii* of Hall.[2]

Both of these species serve to illustrate that distinctness of the Atlantic border area of North America from the inland plateau of the continent, on which I have elsewhere remarked.[3] Both in the Upper Silurian and Carboniferous, the rocks and fossils of Nova Scotia can be more easily correlated with those of Great Britain than with those of New York and Pennsylvania. So much did this fact strike the late Mr. Salter that he even thought it possible to correlate the fossils of the Arisaig section with those of individual members of the English Upper Silurian.[4]

IV.—Is there a Base to the Carboniferous Rocks in Teesdale? A Question for Silurian Geologists.

By J. R. Dakyns, Esq.;

Of H. M. Geological Survey of England and Wales.

During a recent excursion into Teesdale I paid a visit to certain Mica trap-dykes discovered by my friend Mr. W. Gunn, and to a section of the Carboniferous beds below the Whin Sill of Falcon Clints, near Caldron Snout, which suggested the question whether there is not a base to the Carboniferous beds in that part of Teesdale.

The section below the Whin Sill has, I believe, been described by Sedgwick. Suffice it to say that the lowest bed there exposed at the very foot of the crags, just above the alluvium of the Tees, is a breccia that reminds one, who knows the beds, of the breccia so often found at the base of the Carboniferous in Yorkshire. The next section seen in going down the stream is at the old Pencil Mill, on the banks of the Tees below Cronkley Scar. Here the beds, which were once wrought for slate pencils, consist of hardened shale, apparently at a high dip, which the Carboniferous beds of the neighbourhood are not, traversed by several dykes of mica trap. These dykes are quite unlike anything else in the country; but resemble similar dykes in the Kendal country, where they are never known to pierce the Carboniferous beds, but are exclusively confined to the Silurian rocks. The hardened shale traversed by these dykes in Teesdale is not unlike Skiddaw slate, which also was once similarly worked for slate pencils in Westmoreland; but I cannot assert, merely after a short visit on a stormy Sunday afternoon in November, that the shale is not hardened Carboniferous shale, hardened by the dykes: but the beds are as much like Skiddaw slate as Carboniferous shale, perhaps more so; and this similarity, together with the apparent high inclination, and the Silurian character of the dykes, when taken along with the breccia at the base of Falcon Clints, leads one to ask the question at the head of this notice.

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[1] Honeyman, Geol. Journal, vol. xx.

[2] Palæontology of New York, vol. iii.

[3] Acadian Geology and Story of the Earth.

[4] Honeyman, *l. c.*

V.—THE LHERZOLITE OF ARIÉGE.

By the Rev. T. G. BONNEY, M.A., F.G.S.;
Fellow and late Tutor of St. John's College, Cambridge.

THE rock Lherzolite has been described by Prof. Zirkel in his valuable Beiträge zur Geologischen Kentniss der Pyrenäen (*Zeitschrift der Deutsch. Geol. Gesel.*, vol. xix. p. 68), but is generally passed over with the briefest mention or entirely omitted in English works on Geology. Even in Cotta's "Rocks Classified and Described" it is barely noticed, and the word is left out in the index. On this account, and seeing that, so far as I am aware, no description of its microscopic structure has yet been published, a notice, embodying the results of Prof. Zirkel's paper, and of a brief visit of my own to this not very accessible locality, may be useful to students.

Lherzolite is a crystalline aggregate of the minerals olivine, enstatite, and diopside, with some picotite, in texture varying from finely to rather coarsely granular; that from the locality visited by myself being, on the whole, of the former character. It obtains its name from the Etang de Lherz, a small tarn in the Eastern Pyrenees (Dept. Ariége), above Aulus, in the valley of the Garbet, 38 kil. from St. Girons, and near the Col d' Ercé (or Port de Lherz), an easy pass (5341′) leading to Vicdessos in the valley of the Oriége. The rock entirely surrounds the *Etang*, and is the largest of a linear series of seven exposures in the vicinity of Vicdessos.

The Etang de Lherz is a shallow tarn occupying apparently a true rock-basin, the longer axis of which lies roughly N. and S. The water escapes from the northern end by soaking through some peaty ground. On the western side is a tiny island. The tarn is surrounded by rounded masses (probably once ice-worn) and fallen blocks of the Lherzolite, which also rises from the western shore in a craggy hill. A furlong or less from the eastern shore limestone shows through the grass and stretches away in that direction, forming the general mass of the country. The tarn is not in the line of the main valley of the Garbet, but in a sort of open upland glen, a little above the bed of the former. On the opposite side of this rises a bare craggy limestone hill, capping the Lherzolite which forms its base.

The Lherzolite is tough and difficult to break, traversed by many minute, rather irregular, divisional planes, with occasionally a slight tendency to a platy structure. Hence it is not easy to obtain good specimens. The surface of a specimen from the heart of the rock is rough, rather uneven and granular, at the first glance tolerably uniform in colour and apparent composition, of a dark greenish-grey or olive-green colour. A closer examination shows specks of brighter green, generally of two colours, one (the more invariable) an emerald green, the other a waxy-looking duller green; also specks of a resinous pale-brown mineral, sometimes with a platy or fibrous aspect and a dullish lustre ranging from silvery to brassy. Minute grains of an irregularly disseminated black mineral, with a vitreous lustre, are also just visible; and there is another of transparent glassy aspect. The last is only broken olivine. to which the predominant dull-coloured mineral belongs; the emerald green is the diopside; the resinous mineral enstatite; and the black is picotite. The duller green tint is serpentine. The separate minerals are more easily detected in a coarser specimen, which I purchased from Pisani in Paris in 1875, who obtained it from Sem, the easternmost locality along this line of outbursts in the Department of Ariége.

The rock at the Etang de Lherz varies a little in texture, some, especially, as it appeared to me, that towards the outside, being more compact than the rest. When the rock is slightly decomposed the dull green tint becomes more marked, and the compact varieties begin to resemble serpentine. The exterior weathers from a bright yellowish to a dark rusty-brown tint, with a rough surface. On this the projecting pale amber-yellow grains of enstatite, and the bright green grains of diopside, with the black picotite, may be readily distinguished. Occasionally also a sort of linear structure is developed on the surface in weathering; such as I have observed in some of the Lizard serpentine; like this, it has some connexion with an internal parallelism, but the exact nature of it is not yet quite clear to me, though I think it will prove to be connected with a fluidal structure. The brown weathered surface generally extends inwards for about ·1 to ·2 inch; and the change from it to the green rock is pretty sudden, a thin pale band usually intervening, in which the enstatite, diopside and picotite are well distinguished. The rock is traversed by numerous irregular joints, breaking it up into rude polygonal blocks; but now and then the outside of an old weathered surface shows a more regular prismatic structure; occasionally also there is a slight parallelism in its fissures. The more minute joints are lined with a thin film of limonite or of a serpentinous mineral, apparently a green steatite,—often in the latter case so thin as to be a mere glaze. Slickensides are not rare on the joint faces. The general aspect of the weathered rock, the peculiar roughened surface with its irregular fissures, the jointings and contours of the fallen blocks, in shape like masses of broken curd, strongly reminded me of the Lizard serpentine in Cornwall, with which I am very familiar.

Time did not allow me to cross the valley and examine the junction with the limestone on the opposite side, where it was well exposed for a considerable distance at the base of a sort of cliff; but as far as I could see it was rather wavy and uneven, as if the Lherzolite were intrusive. I followed the junction on the east side of the pool for a considerable distance. Unfortunately the abundant herbage, the number of scattered boulders, and the peculiar weathering of the limestone, which forms deep fissures (like the *karrenfelder* of the Alps), harbouring a rich vegetation, prevented me from obtaining a single actual contact: but as the Lherzolite clearly appears here and there to protrude in broad tongues into the limestone, and this is highly crystalline (being quite white and saccharoidal) near the junction, I have little doubt the rock is intrusive. That it is an igneous rock I think no one who has examined it will dispute. There are, however, I think, no proofs of eruption, though a breccia of angular fragments of Lherzolite and limestone might seem at first sight to be a volcanic agglomerate, and so even favour the idea of contemporaneous volcanic action. According to Prof. Zirkel this breccia occurs here (and here only) between the Lherzolite and the limestone. I did not, however, observe it at this part of the junction, but found a dyke-like mass of brecciated Lherzolite on the opposite side of the Etang. The numerous fallen blocks made it difficult to examine this *in sitû*, but it appeared to be about three or four yards wide, and to cut across the Lherzolite roughly from E. to W. As far as I observed, however, this rock was composed only of Lherzolite, and I fully believe it only to be a friction breccia, and not at all of the nature of a volcanic agglomerate. The other masses of breccia which I examined were on the grassy hill-side nearer to the Col d' Ercé, not far from where there is another small patch of Lherzolite on Prof. Zirkel's sketch-map. These, however, appeared to me to be in every case erratics, and I could not see the rock *in sitû* on the hill above. My time, however, was too limited to allow of a long search. These blocks varied from a breccia of angular and subangular fragments of Lherzolite, frequently more than three inches in diameter, imbedded in a ferruginous paste which often appears to consist mainly of minute fragments of Lherzolite, to an extremely pretty rock chiefly composed of fragments of white marble, often from a half to one inch diameter, imbedded in a speckly yellowish or greenish grey matrix, with a slight ruddy tinge. In the time at my disposal I collected four varieties of the breccia, forming a fairly complete series. The first is exclusively made up of Lherzolite, and so thoroughly compacted that (as in many ancient breccias) it is often not easy to distinguish the fragments, except on a weathered surface. The second consists mainly of Lherzolite fragments with a very few small pieces of marble, but here and there there is an appreciable proportion of minute calcareous fragments in the matrix. In the third, the marble predominates, but the paste contains a large quantity of comminuted Lherzolite; and in the fourth fragments of marble abound, but those of Lherzolite are rare, though this rock is represented to some extent, as in the last, in the paste. In this (in the last two cases) one can readily distinguish bright green fragments of diopside and rather numerous black grains of picotite, apparently imbedded separately.

This mass of Lherzolite is the largest of the seven exposures in the district, and according to Prof. Zirkel is about 1300 yards in greatest length. Three other masses lie near it along the line of the little glen of the Suc. The rest are near its junction with the Oriége, one being on the opposite bank near the village of Sem. All are in the Liassic rocks, and, except the last, are very near their junction with the granite, which even here is at no great distance. It is also more coarsely granular than the rock at the Etang, and the breccia is wanting. Lherzolite also occurs near Portet d'Aspet, in the upper Val longue (Castillon), and on the south side of the Col de Lurdé, in the neighbourhood of Eaux Bonnes. The principal rock here is a limestone with ophite, *i.e.* greenstone, near it. I have not seen any of these.

The rather compact condition of the rock, and the fact that the olivine is in some specimens rather green, and the diopside a little dull in colour, while the enstatite does not always exhibit its characteristic structure, makes it often very hard to distinguish the component minerals of the specimens from the Etang de Lherz. They are better seen, however, on a polished surface, and can be separated, as Zirkel suggests, by treating the pounded rock, first with hydrochloric acid, and then boiling it with caustic potass. In my Pisani specimen from Sem, the minerals are much more easily distinguished, as is the case also, according to Zirkel, in his specimens from this locality. The composition of the Pyrenean Lherzolite is according to an old analysis (Zirkel, p. 140):—SiO_2=45·0, Al_2O_3=1·0, CaO=19·5, MgO=16·0, FeO=12·0, CrO=0·5, with a trace of MnO and loss=6·0. Lasaulx gives the analysis of a Lherzolite from Norway (Elem. der Petrograph. p. 338):—SiO_2=37·42, Al_2O_3=0·10, MgO=48·22, FeO=8·88, MnO=0·17, NiO=0·23, H_2O_2=·71.

The rock varies slightly in different parts around the Etang, both in grain and in preservation. I collected specimens chiefly from near the southern end, and about half-way down the west side; the most serpentinous specimens coming from the former. Mr. S. Allport, to whom I gave a duplicate from Sem, kindly cut me a beautiful slide from it, and I have had slides (six in all) cut from three varieties collected by myself at the Etang. I will refer to them as No. I. (from Sem [Pisani]), No. II. (specimen from the west side), No. III. (specimen from the south end), No. IV. (specimen showing a partial passage into serpentine). This specimen was cut close to a joint face where the change was greatest.

Microscopic Structure.—In all cases the rock is normally composed of olivine, enstatite, diopside, and picotite, with occasional minute specks and microlithic aggregates of an opaque black mineral, probably magnetite. Microliths of other minerals are rare. The first three minerals all occur in variable shaped grains; those of the olivine roundish; the diopside occasionally showing a slight oach to a regular crystal outline; the enstatite usually irregular longish; the olivine appears to have crystallized the first, but ink the difference has not been great. It generally forms about the whole mass of the rock. The picotite, from its shape, seems ıve crystallized last.

he olivine occurs in more or less rounded, transparent, colourless ıs, very irregular in size. Surface finely granular, something frosted glass. Colours with crossed Nicols often very beautiful, monest from a translucent greenish yellow to a yellowish green, from a bright to a purplish pink. Owing to the peculiar texture, of these tints often overspreads the other something like a shot The mineral shows the usual rather irregular cracks, indi- ıg its imperfect cleavage. These often cause, by imperfect sion, colour bands, which are also common near the edges of grains. Not seldom we find in the olivine small vermicular ties arranged in slightly wavy bands. These appear to be etimes empty, sometimes filled with a brownish mineral, perhaps peroxide. They lie in some cases in the planes of imperfect sion, and then have often a dendritic character. There are sional clots of an opaque dust-like mineral, probably magnetite, thin fibrous brown films, strongly dichroic, which may either be e stains or minute plates of iron-glance. The last are often ciated with the picotite.

he enstatite is transparent, colourless in ordinary light, with a finely ıular or slightly silky texture. The cleavage parallel to $\infty\breve{P}\infty$ enerally well exhibited, though not so close as a rule as in lage; a more interrupted cleavage parallel to $\infty\bar{P}$ is also some- s fairly distinct, as in Rosenbusch, Mikroscop. Physiogr. Tab. 44. In cases where the specimens have a less characteristic ct, I have found the principal cleavage planes better exhibited otating the microscope stage till the plane of the principal cleavage arly parallel to the plane of vibration of one of the crossed Nicols, n, as the crystal approaches its darkest aspect, the fine cleavage mes more clearly visible. This method (proposed by Tschermak) listinguishing the orthorhombic enstatite from the monoclinic lage will be found very useful in examining Lherzolite. The tals show sometimes wavy bands crossing roughly at right les the lines of the principal cleavage, formed apparently by ute elongated cavities and microliths. Colours with polarized t pale yellowish or greyish to various blues.

he diopside is not generally in well-formed crystals; it is pellucid he thin slices, and sometimes still retains a faint tinge of green. h polarized light, the colours are less diaphanous in aspect than e of the olivine, rich yellowish-brown and puce tints being mon. The surface is rather variable, but generally moderately gh-looking, with often a slightly "stepped" aspect. The acteristic cleavage, as in augite, is commonly well developed.

he picotite occurs in very irregular grains or groups of grains, or ı films, often looking as if a point armed with a sticky fluid been drawn for a short distance along the slice. Surface rather rough-looking, something like that of augite. Colour a translucent rather deep olive green, occasionally slightly inclining to brown, in No. IV. a rich umber brown. Rosenbusch (Mikroscop. Physiog. p. 160) gives the colours of picotite as yellow to brown, transparent to opaque; stating that Pleonaste differs from it in having green tints. If this distinction be correct, the mineral in slides I., II., III. must be Pleonaste. The grains are traversed by rather irregular cracks, which occasionally indicate a rude cleavage. IV. is less rich in picotite than the rest. As the mineral is isometric, it is of course dark between crossed prisms.

Of the various slides, No. I. is the best for study of the rock, as it is more coarsely crystalline, and shows little or no indication of decomposition. No. II. shows the grains of the minerals a little more rounded than No. I., and all are much cracked. The olivine appears to bear a rather smaller proportion to the other minerals than in I., and the diopside shows a rather smoother texture. The cracks in the olivine are often bordered on both sides by a finely fibrous serpentine, the result of decomposition. It remains bright. generally of a pale golden hue, between crossed prisms. No. III. is in structure similar to II., but with more olivine; here decomposition has advanced further, giving parts of the slide a muddy look, probably due to faint stains of peroxide of iron; the serpentine strings are often abundant enough to form a kind of network in the olivine, and one considerable crack across the slide is filled by a feebly double refracting serpentinous mineral. There is a sort of parallel structure perceptible in the direction of the principal cracks, marking a parallelism in the axes of the crystals, and the same is to a slight extent perceptible in the arrangement of the minerals.

No. IV. gives indications of a structure similar to III., but the change here is much more considerable. A network of serpentinous strings covers almost the whole slide, in many cases invading the other minerals; the cracks of which are usually free from serpentine in II. and III. In parts the strings seem to coalesce, so as to convert appreciable portions of the slide into serpentine. Here it is interesting to note that clots of opaque dust, doubtless oxides of iron, resulting from the separation of the constituents of the olivine, appear among the strings just as we see them, for example, in the Lizard serpentines.

These slides therefore exhibit to us, and this is the most interesting aspect of the rock, the commencement of the formation of serpentine. In certain serpentines—as, for example, those of Elba, and, as I have recently discovered, of the Lizard—and in some of the olivine bearing gabbros, we can trace the process from specimens from which all the olivine has disappeared, and the alteration into serpentine is complete, to those in which a considerable amount of unchanged olivine is still to be detected. We have thus a further confirmation of the idea, now becoming not unfamiliar to geologists, that much serpentine is an altered olivine rock.

VI.—CONSIDERATIONS ON THE FLOTATION OF ICEBERGS.

By Professor JOHN MILNE, F.G.S.,
Of the Imperial College of Engineering, Jeddo, Japan.

all our text-books of Geology, the action of floating Ice is referred to as an agent of great power in producing physical ges. Its two chief forms are those of Coast Ice and Icebergs. h has been written about the latter of these, but about the er very little. In the GEOLOGICAL MAGAZINE, July, 1876, in an le on Ice and Ice-work in Newfoundland, I endeavoured to show the greater agent of the two was Coast Ice, a view which has subsequently strengthened by observations on the Coast of land. In this paper I had occasion to refer to the laxity with ch the conditions under which Icebergs float have been spoken ut. Thus, in Jukes and Geikie's Text-Book of Geology, p. 416, are told that because "about eight times more ice of an iceberg elow water than above," therefore "a mass which rises 300 feet ve the waves has its bottom 2400 below them."

s no regard is paid to what the relative shape of ice above water that below, might it not be well to add, in order to render the mlessness of the doctrine more evident, that the mere fact of ting a Union Jack upon the summit of the berg would cause an ition to its depth equal to eight times the height of the pole?

f this were only done, Icebergs might be talked about as grounding ery deep water, where they could "tear up the softer deposits of sea-bed," and "rub down and groove the harder rocks" to an imited extent. This grounding in deep water I endeavoured to w to be, in the generality of cases, untenable, excepting, perhaps, he case of bergs immediately in the vicinity of their origin, where more or less approximate to parallelopipeds in their form. In g this, I also showed that in consequence of the degrading action ich takes place, more especially between wind and water, it would n that bergs as they travel towards low latitudes must be looked n as a form more like a peak which stands upon a sunken estal or foot, rather than as descending perpendicularly into the er. In such a case it is evident that no great depth could be ined.

owever, to take as favourable a view as possible of ice reaching n to abyssal depths, I will again assume a case which I took re (GEOLOGICAL MAGAZINE, July, 1876, p. 307), where we must gine the portion of the berg beneath the water to be a general tinuation of that above.

uch a figure I showed might be regarded as approximately equal cone or many-sided pyramid. In such a case I have shown hematically that *the depth of ice below water is approximately l to the height which is exposed above,* the slight difference which exist depending on the ratio we take as existing between the ific gravity of ice and sea-water,—a conclusion from which I ot see the slightest reason to alter.

his being the *case, it consequently* follows that if it is accepted that bergs exist at all approximating to that of a pinnacle standing upon a base, *the depth to which they may extend below the surface of the water is less than the height we see above*, and therefore in many cases, when we see a berg 300 feet above the water, we may with much reason assume that its depth beneath the surface of the water is less than 300 feet.

The case which I have considered is one which appears to be applicable to many icebergs, and, I think, to the generality of them.

It now remains to see how far such views may be carried, and also, for the sake of illustration, to consider the possible conditions under which some other forms of ice may be regarded as existing.

In the paper where the conclusion just referred to was arrived at, a cone approximating to a berg of ice was drawn as floating with its base downwards. The Rev. O. Fisher (GEOL. MAG., 1876, p. 379) has, however, raised the question of the stable equilibrium of such a cone, which he thinks would not remain in the position as figured, but must turn over. Whether this would or would not be the case with the cone in question, I am not prepared to answer. The figure is only drawn to illustrate the calculation to which it is appended. As a practical illustration, to strengthen these views and to show that the cone of ice which I have taken will not float with its base downwards, Mr. Fisher takes a tetrahedron out of a set of models of crystals, and placing it in water finds that it floats with one of its angles downwards.

This I consider to be an unfair comparison, which no doubt has led many casual readers to the belief that a cone will also float with its apex downwards, and perhaps, in consequence, that my conclusions, being founded on false assumption, must also of necessity be false. Lest readers should be led into misconceptions of this sort, it may be well to consider how cones of ice would float.

First, if we take a slab of ice and place it upon water, we know that it will float horizontally. On the middle of this slab we might raise a small pinnacle of ice, and the mass would still keep horizontal. We might next increase this pinnacle round its sides without increasing its height until we reached the edges of our slab, and still we may imagine the block we have built up keeping its horizontal position. We should here have a figure approximating to the probable shape of an iceberg which has travelled into latitudes like those of Newfoundland,—a pinnacle supported on a foot or pedestal. Such a form approximates to a cone, and such a cone I believe would float, and does float with its base downwards, or in other words, from a consideration of this sort, it is evident to us that there are certain obtuse cones which would float with their apex upwards. Secondly, on the other hand, if I make a very acute or tall cone, it would never for a moment be expected to float vertically with its base downwards more than a tall stick of ice would be expected to retain such a position. Such a cone would, according to ordinary expectation and according to all probability, fall on its side and float more or less horizontally. It is also equally certain that such a *cone would not* float with its apex downwards, as Mr. Fisher's ex*periment might lead* one to think.

Being thus convinced, from our own sense of reason, that there are cones of ice which can float with their base downwards, and also that there are others which can float with their base upwards, the question then is to define these cones.

1. Adopting from Thomson and Tait, Natural Philosophy, § 767, that where V is the volume of a body immersed in a fluid, A the area of its plane of flotation, k the radius of gyration of that plane, and h the height or distance between the centre of gravity of the floating body and that of the displaced fluid, for stable equilibrium we must have

$$A\,k^2 > V\,h$$

We shall find for a cone of ice to float with its vertex downwards n sea-water, the radius of the base of the cone must be greater than 196 times its height,—*or, roughly, the diameter of the base cannot be less than two-fifths of the height.*

2. Again adopting the same method for a cone of ice floating in sea-water with its base downwards and horizontal, we shall find that the radius of the cone must be greater than 1·05 times its height,—*or roughly the diameter of the base cannot be less than twice the height.*

Note.—Case I.[1] Moment of Inertia of a circular lamina about a diameter$=\frac{\pi R^2}{4}$, but this $=Ak^2$

$$\therefore Ak^2=\frac{\pi R^2}{4}$$

$$\text{or } \pi R^2k^2=\frac{\pi R^4}{4}\ \therefore k^2=\frac{R^2}{4}\ \therefore k=\frac{R}{2}$$

Let r be the radius of the base of the cone and a its height. Also let he density of the floating cone compared with the liquid be ρ, then—

$$AC:BC=1:\rho^{\frac{1}{3}}$$

$$\therefore \text{radius of plane of flotation is } r\rho^{\frac{1}{3}}$$

$$\therefore \text{radius of gyration } k=\frac{r\rho^{\frac{1}{3}}}{2} \qquad (1)$$

he Area of the plane of flotation

$$A=\pi r^2\rho^{\frac{2}{3}} \qquad (2)$$

Let G be the centre of Gravity of the Cone and E that of the dislaced water,

$$GC=\frac{3a}{4} \text{ and } EC=\frac{3}{4}\,a\,\rho^{\frac{1}{3}}$$

$$\therefore GE \text{ or } h=\frac{3a}{4}\,(1-\rho^{\frac{1}{3}}) \qquad (3)$$

the immersed volume$=$the volume of the Ice Cone multiplied by

$$\rho \text{ or } \frac{\pi r^2 a}{3}\,\rho \qquad (4)$$

ow substituting in $Ak^2 > Vh$

$$\pi r^2\rho^{\frac{2}{3}}\cdot\frac{r^2\rho^{\frac{2}{3}}}{4} > \frac{\pi r^2 a}{3}\rho\cdot\frac{3a}{4}\,(1-\rho^{\frac{1}{3}})$$

$$\text{or } r > a\sqrt{\frac{1}{\rho^{\frac{1}{3}}}-1}$$

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[1] See Woodcut, Fig. 1, p. 69.

Now if the specific gravity of ice $=1\cdot028$ and that of sea-water $\cdot918$, then ρ for sea-water and ice $=\cdot893$

$$\text{whence } r > a\ \cdot196$$

CASE II.[1]—As in Case I. let r=the radius of the base of the cone, a=the height of the cone, and ρ as before.

Volume of Cone ACM : vol. of BCN :: $1:1-\rho$ $\therefore$ AC : BC $=1:\sqrt[3]{1-\rho}$

$\therefore$ radius of plane of flotation $=r\ (1-\rho)^{\frac{1}{3}}$ and k the radius of gyration of plane of flotation $=\frac{r}{2}(1-\rho)^{\frac{1}{3}}$ (1)

$$\text{Area A of plane of flotation} = \pi r^2(1-\rho)^{\frac{2}{3}} \qquad (2)$$

The distance between G and E which are as before, or $h=(\frac{1}{\rho}-1)^{\frac{3}{4}}\cdot a\ (1-\sqrt[3]{1-\rho})$ (3)

$$\text{V the volume of displaced water} = \frac{\pi r^2 a\rho}{3} \qquad (4)$$

$$\text{Now substituting in } \mathrm{A}k^2>\mathrm{V}h$$

$$\pi r^2(1-\rho)^{\frac{2}{3}}\frac{r^2}{4}(1-\rho)^{\frac{2}{3}}>\pi r^2\rho\frac{a}{3}\cdot\left(\frac{1}{\rho}-1\right)^{\frac{3}{4}}\cdot a\,(1-\sqrt[3]{1-\rho})$$

$$\text{or } r>a\sqrt{\frac{1}{(1-\rho)^{\frac{1}{3}}}-1}$$

$$\text{or } r>a\ 1\cdot05$$

Approximations to these two limiting cones are represented in the woodcuts given on page 69. Fig. 1 represents a cone of ice floating with its apex downward, which is unstable, and in sea-water might fall on its side, whilst one less acute might float in this position. Any cone, when thus floating, has about $\frac{1}{25}$ of its whole depth above water. If such cones existed in nature, it is evident that they must be much more obtuse in form in order to withstand in such a position the shocks of waves and winds to which they would be subjected.

Fig. 2 represents a cone of ice floating with its apex upwards, and its base horizontal. Any cone which is more obtuse than this, when floating in sea-water, is stable. In this case ·47, or, as before stated, nearly one-half of the height of the cone, is above water.

To test these results I had several small cones made out of Japanese boxwood (S.G. about ·839), which was the most suitable wood for the purpose which I could obtain. The diameter of the base of these cones was in all cases 2 in., whilst their height, which was variable, was made above and below the limits as given by calculation where the specific gravity of the wood I was using took the place of the specific gravity of ice. These cones, when placed in water, behaved in a manner similar to the way I have stated that cones of ice will act.

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[1] See Woodcut, Fig. 2, on opposite page (p. 69).

We have here the solution to two theoretical cases of supposed bodies of ice floating in sea-water, which I think will considerably aid us in forming some idea as to the depth to which icebergs extend beneath the surface of the water,—the practical solution of which problem is surrounded with so much difficulty. The results are obtained from two regular solids, but yet it is evident that they can be roughly applied to any solids which approximate to such forms. Now from Case I., where cones floating apex downwards are considered, it is evidently possible for floating ice to have a depth below the surface of the water in comparison to that which is above immensely greater than has generally been believed. But the question now is, have forms approximating to such inverted cones any existence in nature? All that I can say to the contrary is by appealing to the results of observation and to the consequences of degradation upon a block of ice after leaving its parent the glacier,—both of which, as pointed out before (Geol. Mag. 1876, p. 306), appear unfavourable to such views.

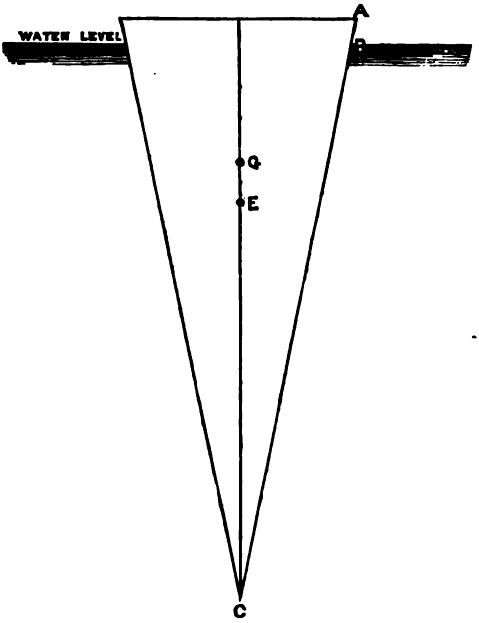

Fig. 1.

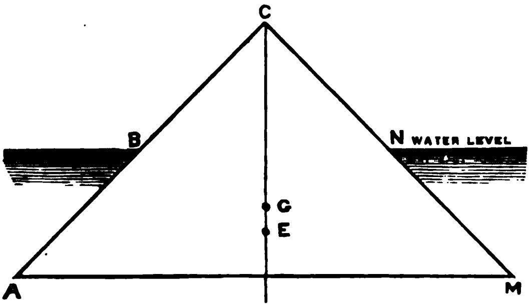

Fig. 2.

I might also add, as another argument against the probability of ice extending to abyssal depths, that pressure tends to liquefy ice, or, in other words, to lower the freezing-point of water, and ice at great depths is under *great pressure*. For example, ice at the depth of 2400 feet would be under a pressure of about 73 atmospheres. Although this lowering of temperature, which can be easily calculated, is very small, it must nevertheless have some influence in the destruction of masses of ice should they extend to considerable depths, more especially so when we consider that the action is not merely a surface one, but one that extends throughout the mass.

The more probable form in which the generality of icebergs exist are those which have their limit represented by Case II., where we have a series of stable forms, more or less conical in their shape. Here the depth below the surface of the water never exceeds the height which is above, but is probably always less.

Of course many other forms of ice also approximating to regular solids might be supposed, in which the ratio of the depth of ice below water to that which is above would be greater than that of the inverted cone, and which would be less than that of the upright cone. Thus, for instance, such a solid as would be described by an equilateral hyperbola, revolving round one of its asymptotes, might be taken as pointing downwards or upwards. In the former case the ratio of the depth below the surface of the water to the height which is above might be infinitely greater than in the case of the inverted cone of ice, and in the latter case or pointing upwards the ratio of the depth below the surface of the water to the height which is above infinitely less than in the case of the upright cone.

To obtain the greatest height of ice above the surface of the water relatively to that which is below we must imagine a sheet of ice, from the upper surface of which a needle or pencil extends vertically upwards. The same figure reversed would give us the greatest depth to which ice could descend below the surface of the water. Such a case is however purely theoretical. In cubes which are in stable equilibrium with a face upwards, and in parallelopipeds which are in stable equilibrium with one of their largest faces upwards, the depth of ice below the surface of the water would be about eight times the height which is exposed above.

Combinations of regular solids might also be considered. Thus two cones might be supposed placed base to base, and floating one with its apex upwards and the other with its apex downwards.

First—let the volume of the lower cone V, whose height is H, be eight times the volume of the small cone v, whose height is h.

In this case we have

$$\frac{V}{v} = \frac{H}{h} = \frac{8}{1} \therefore H = 8\,h$$

or the depth below the surface of the water is eight times the height which is above.

Secondly—let the upper or smaller cone be less than $\frac{1}{8}$ the volume of the lower one, then the depth below water will be greater than eight times the height above.

Thirdly—let the upper or smaller cone be greater than $\frac{1}{8}$ the volume of the lower one, then the depth below water will be less than eight times the height which is above.

Continuing in this way, a number of cases might be considered which would show us that in some cases the depth of ice below the surface of the water is eight times that which is above, in some cases less than eight times, and in other cases greater than eight times.

What now remains to be done is to take the case which seems to be, for the generality of icebergs, the most probable one. This I believe to be the case where we have a pinnacle standing on a foot or pedestal, or in the limiting case a cone floating with its apex upwards. In this case *the height above the surface of the water will be generally greater than the depth which is below.* Until future observations show this view to be a wrong one, I think I shall be justified in keeping to the above result.

VII.—NOTES ON CORAL REEFS.

By STAFF-COMMANDER HENRY HOSKEN, R.N., H.M.S. *Pearl.*

[Communicated by R. H. Scott, F.R.S., Director of the Meteorological Office.]

I HAVE to thank you for your kind letter of the 24th of December, 1875; it affords me great satisfaction to hear that my remarks about the New Hebrides[1] have interested you.

Thinking that my observations on the soundings that I obtained off the east end of Vanikoro Island, Santa Cruz Group, might be useful, I propose to forward a copy of them, together with tracings, with the next Log that I shall complete and send into office; the originals were forwarded to the Hydrographical Department on the 31st December, 1875. A new edition of the Chart No. 986 with corrections has since been issued.

The chief interest of this discovery is not so much in its hydrographical importance, as in its connexion with the probable alteration of the geological formation of these reefs, or else, allowing that they existed at the time of the Survey, it shows that this "Barrier Reef" is not so different from the general rule as was at first supposed, when the Chart showed a gap of eight miles in the reef.

Before our arrival at Vanikoro Island, Commodore Goodenough and I had been remarking on the peculiarity of the apparent cessation of the "Barrier Reef" on the weather side of that island.

The *Pearl* was taken into the anchorage of Ocili Harbour, Tevai Bay, under sail, a strong Trade was blowing; when nearly abreast Dillon Head, and steering in on the course recommended, a shoal spot, upon which the sea occasionally broke heavily, was seen; this was only cleared by about a ship's length; particulars are given in copy of remarks. The patch appeared to consist of live coral.

Whilst the *Pearl* was steaming out, several soundings were obtained, and much discoloured water seen over shoal-looking ground, the description of which is given in Remarks, and the position shown in the tracings already alluded to.

It had been Commodore Goodenough's intention to have taken the *Pearl* inside the "Barrier Reef," but eventually it was considered advisable to round the island outside it, whilst he, with some of the officers, went in the boats and visited the villages on the south and west coasts. This was the last friendly reception that the late Commodore had from the natives, for it was on the following day that he received his death wound at Santa Cruz.

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[1] See GEOL. MAG. 1876, Decade II. Vol. III. p. 82.

It is fortunate that the *Pearl* was not piloted inside the "Barrier Reef," for the lagoon space was reported (on the return of the boats) to be full of patches of growing coral, which rendered the passages too intricate for a vessel of her size. You will gather from my remarks, that I consider these sunken shoals to be a continuation of the "Barrier Reef." The following questions therefore arise: have these shoals grown up since the survey in 1828 by Capt. Dumont d'Urville? or did they exist at that time, and were by some mischance not discovered? The survey, in other respects, appears to be such a good one that I am loath to believe that the latter is the case.

Mr. Darwin, in his second edition, revised, of the "Structure and Distribution of Coral Reefs," pp. 64, 167, and 216, mentions this "Barrier Reef," and that the level of the islands has been affected by earthquakes; also Prof. Dana, in his English edition of "Corals and Coral Islands," p. 307, refers to the same thing.

With respect to the coral patch off Dillon Head, had it existed at the time of the Survey, it could not well have been overlooked, for it was distinctly visible (with an occasional heavy break over it during our stay) from the anchorage. Another reason for believing that alterations have taken place in the harbour, is found in the names that were given to the other two shoals, leading one to imagine that they would be difficult to be made out, whereas they appear always to have a break upon them, and can be plainly seen; the terms "Deceitful" and "Treacherous" would scarcely have been applied to these most apparent dangers had they in the year 1828 been in their present state.

On the west or lee side of Vanikoro Island there were several large stones of coral rock, well above the water, lying on the "Barrier Reef," which were not shown upon the chart.

Contrary to what one generally finds with respect to these reefs, the highest part is to leeward and the sunken position to windward.

Tapoua Island, which lies 20 miles N.W. from Vanikoro, has a "Barrier Reef," but Santa Cruz, which is 40 miles further to the N.W., has not any; a fringing reef borders portions of the coast, but it is not continuous.

VIII.—High-Level Terraces in Norway.

By J. R. Dakyns, Esq.;

Of H. M. Geological Survey of England and Wales.

In the summer of 1872 I visited Norway, and wrote the following brief notice of certain high-level terraces immediately on my return to England, but kept it back that I might first consult some papers on Norwegian terraces that had appeared in the closing numbers of "Scientific Opinion"; these I was not able to meet with for so long a time that I gave up the idea of sending my notice to the press. I am now induced to do so, because I see that the subject of the parallel roads of Glenroy still occupies the attention of geologists, and it may induce some one next summer to examine minutely the Dovre terraces and sand-heaps and their relation to the physical geography of the district. I was merely able to make a flying visit to them, which I delayed my party to do, because they caught my eye so forcibly, as we were driving along the valley.

The papers in "Scientific Opinion," which I have since seen, do not deal with high-level terraces such as those above Dovre.

It is well-known that Norway has risen above the sea-level to the extent of 500 or 600[1] feet within comparatively recent times. This is known from two kinds of evidence, that of marine shells, and that of raised beaches, terraces, and sea-marks. Marine shells of recent species have been found at a height of 470 feet (? Norwegian) according to Kjerulf.[2] As to the other kind of evidence, it is to be met with universally. At the head of every fjord a series of terraces of sand and gravel is to be seen, sometimes more, sometimes less numerous, lining the side of the dales, and corresponding with distinct lines of old wave-action, which can be traced for miles running along the mountain-sides above the sea. These terraces were clearly formed in the same manner as the present delta of sand and gravel, which is now forming at the head of every fjord, and which another rise of the land would convert into a similar terrace.

Such terraces are more or less numerous according to the accidents of denudation; each separate terrace marking at least one step and pause in the elevation of the land. I made this year (1872) various barometric observations of the height of the best-marked of these terraces. There is one at Söholt, on the Stor Fjord, about 180 feet above the sea-level; one at Hellesylt, on the same fjord, 270 feet above the sea-level,—this is a very well marked one. A large and well-marked terrace at Odde, on the Hardanger Fjord, is between 200 and 300 feet high. At Sogndal the highest flat is 460 feet above the sea, but no section of sand or gravel was to be seen, the solid rock showing at the surface. The highest terrace of sand and gravel is 374 feet above the sea. Above this level the solid rock shows, though the level step at 460 feet looks like an old sea-margin.

The above heights of course are mere rough approximations; but there is no doubt that the terraces in fjords show an elevation of about 400 feet, and that corresponding sea-margins can be traced outside the limits of the dales above the sea itself.

The Norwegian geologists do not admit a greater elevation of the country than to the extent of 500 or 600 feet, because they have not found any marine shells above that height. In the year 1869 I noticed several well-marked sea-margins on the Norwegian coast in the neighbourhood of Tromsœ, and my impression is that the highest of these is more than 500 feet above the sea (but a landsman is a bad judge of heights and distances across water). This year (1872) I found sands and gravels, apparently precisely similar to the lower terraces, at Haugen, on the watershed as you cross from the Stor Fjord to the Nord Fjord, at the height of 1100 feet above the sea. This sand I judged by the eye to reach as high as 1200 feet; and my impression is that it was merely a part of a terrace stretching for a great distance along the hill-side well over the watershed.

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[1] Sir C. Lyell says 700, "Principles," 11th ed. p. 133.

[2] Kjerulf says in his "Jagttagelser over den Postpliocene eller glaciale formation, Universitats-program for förste halvaar," that marine shells have been found up to 470 feet above the sea-level.

But the best instance I know of high-level terraces, similar in all respects (except the all-important one of position) to those acknowledged marine ones at the heads of fjords, is in the Gudbrandsdal and on the watershed between that dale and the Romsdal. The traveller going north ascends between Laurgaard and Broendhaugen by a rocky defile to a rolling plateau covered with sand-hills arranged in irregular mounds. Just before reaching Dovre on this plateau, the road crosses a bridge, where a stream from the west joins the main river. This stream issues from a narrow glen, by which a road leads to Vaage, and the mouth of this glen, just where it opens out upon the main valley, is occupied by terraces of sand and gravel precisely similar to those at the heads of fjords; and the top of these terraces coincides with a distinct mark, which runs horizontally along the hill-side as far as the eye can reach, till it is lost to sight round the gable end at the descent above Laurgaard. This mark might, were the beds flat, be taken for an escarpment; but it is nothing of the sort. The beds are highly inclined, and the mark runs horizontally along the solid rock for miles across the bedding.[1] On the opposite, or east side of the valley, is a corresponding feature, apparently at the same height above the stream. Dovre is marked on the pocket map of the "Reise Ruter i Norge" as 1500 feet above the sea; and it is not much higher than the bridge. The top of the terrace is by aneroid between 400 and 500 feet above the bridge. This would make it about 2000 feet above the sea. Judging by the eye, it reaches very nearly, if not quite, as high as Dombaas,[2] which is given on the map as 2100 feet above the sea. This horizontal water-margin can be traced along the west side of the valley at least as far north as Holset, where a large valley coming in from the west shows sand-terraces. The main valley is very flat all the way from Holset to Lesjiværk and Molmen, between which places is the lake flowing both ways, and therefore on the very watershed. The terrace and its accompanying water-mark are therefore up to the level of the watershed, if they are not actually higher.[3] This is a point which can only be settled by a proper examination of the ground: and a very important point it is, for it makes all the difference between the terrace being due to marine action and to the waters of an ice-dammed lake. If the top of the terrace is above the summit level of the pass, it will be difficult to avoid the conclusion that it is an old sea-margin. At the time I first saw the water-mark and terrace, I had no hesitation about ascribing them to the sea; but on returning to England, I found that the Norwegian geologists do not admit so great a depression. I cannot see that the mere absence of shells is an insuperable objection to the beds in question being marine; for surely the climate might have been unfavourable to the existence of shell-fish.

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[1] The Norwegian Geological Map marks the beds as striking directly across the main valley, but no amount of dip is given.

[2] For any one wishing to make an extended examination of the country, Dombaas would be very good head-quarters. There is an excellent inn there.

[3] From this point I have departed from the text of my original manuscript in *order to indicate the two* possible solutions that appear open to us.

If, on the other hand, the said terrace is on a level with the watershed (and there is certainly no great difference between them), one is irresistibly led to think of the similar case of the parallel roads of Glenroy, and to speculate on this terrace too having been due to the waters of a gigantic Marjelen See, dammed back by ice till it overflowed the summit of the pass at Molmen; and it is significant that I could see no trace of terrace or water-mark on the Romsdal side of the pass.

But the above is not all. There is in the same district a second horizontal mark on the solid rock, several hundred feet higher than the 2000 one. This, too, appears to correspond with sand-terraces in the recesses of the high glens; but I was not able to visit it, and can form no more than a guess as to its height; it probably is as high as the plateau of the Dovre Fell,—that is, more than 3100 feet above the sea. This plateau I know to be covered with large gravel mounds between Dombaas and Folkstuen. Here, again, it is striking, that the water-mark should seem to correspond with the level of a watershed. But it is useless to speculate, and would be absurd to offer an opinion on the subject without examining the ground. I will merely say, that only one of two conclusions seems open to us; either the terraces and water-marks are old sea-margins, or else they are the margins of huge ice-dammed lakes.

The fells rising above the high-level terraces and water-marks are rounded, and of a general moutonnéed look. This general glaciation of the high fells must have taken place either before or simultaneously with the deposition of the terraces, as any subsequent ice-sheet would inevitably have swept them clean way.

The Norwegian Geological Map represents the valley, above and below Dovre, for the distance of forty-one kilometres, as occupied by alluvial and post-glacial sand; but whether this is intended to include the high-level terraces as well as the sand-heaps in the valley bottom I do not know, but presumably it is.

NOTICES OF MEMOIRS.

I.—Ondulations de la Craie dans le Nord de la France—Deux Systèmes de Plis,—Age de ces Plis. Par M. Hébert.

(Annales des Science Géologiques, tom. vii. No. 2, Paris, 1876.)

In a paper read before the Société Géologique de la France, in June, 1875, M. Hébert described a series of nearly parallel folds in the Chalk of Northern France, running in a general direction from S.E. to N.W. These folds, five in number, he distinguished as the axes of Perche, the Seine, Bray, Bresle, and Artois.[1] These are crossed almost at right angles by a second set, also nearly parallel, whose general direction is consequently about S.W.—N.E. To describe this second series, and to advance some general views on the probable age of the folds in both, is M. Hébert's object in the paper under consideration.

The first fold of this second series starts at Rouen, and runs in a straight line through Aumale to Pecquigny, whence it is prolonged in a N.E. direction, passing a little to the south of Arras towards Douai and Tournay.

The second brings the Glauconitic Chalk to the surface at Pressagny l'Orgueilleux and La Madeleine, near Vernon, and passes in its north-east extension close to Breteuil (Oise), cutting the axis of Bray a little to the south of Ville-en-Bray. If prolonged in a south-west direction, it would pass between Evreux and Conches by the important fault which has determined the outcrop of the Glauconitic Chalk in the valley of the Iton.

The third fold runs along near the shores of the Channel. Starting from Pétreval, near Fécamp, it extends with a curve, or bend, to Dieppe, where it is probably represented by the fault described in a previous paper.[2] At both Fécamp and Dieppe the beds dip at a higher angle on the N.W. than on the S.E. side. Supposing it to continue in the same direction on leaving Dieppe, it would then pass through Beaurainville, north-west of Hesdin, intersect the axis of Artois at Fruges, and terminate at Dennebrœucq, where the Devonian beds crop up.

The presence of these several folds leads the author to conclude, in opposition to several eminent English geologists, that one, if not more such folds exist in the bed of the Channel, which will offer serious obstacles to the construction of a tunnel in the Chalk as proposed. That such undulations do exist there, he considers to have been conclusively proved by the soundings conducted by MM. Potier and De Lapparent. One of these (the fourth of this series) would be nearer to the English than the French shore, but parallel to the Sandgatte coast, and consequently to the other three.

The fifth and last of the series is also the southernmost. Commencing at Ferté-Bernard, it stretches in a N.E. direction, past Beynes to Compiegne, and is exactly parallel to that between Vernon and Breteuil.

Respecting the ages of the folds of both the S.E.-N.W. and S.W.-N.E. series, M. Hébert comes to the following conclusions:—

1. The first, or oldest, is the synclinal fold, in which the Wealden

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[1] The correspondence of some of these axes with others on this side of the Channel had already been pointed out by M. Ch. Barrois in a communication read before the same Society in March, 1875. Thus the axis of Artois is probably represented by that of Kingsclere; the axis of Bresle by that of Winchester; and the axis of Bray by that of the Isles of Wight and Purbeck.

[2] Bull. Soc. Géol. de France, 2^e série, tom. xxix. p. 586, and *ibid.* 3^e série, tom. iii. p. 526.

beds were deposited; in age between the Jurassic and Cretaceous periods; and belonging to the S.W.-N.E. series.

2. The second, also synclinal, is the depression of the Somme; in age, between the Wealden and Neocomian; belonging to the S.E.-N.W. series.

3. The third, also S.E.-N.W., is the first indication of the elevation of the Boulonnais and the Weald, and took place between the Gault and Glauconitic Chalk periods.

4. The fourth is the S.W.-N.E. anticlinal ridge from Ferté-Bernard to Brunelles.

5. The three S.E.-N.W. folds of the Perche hills follow next, posterior to the Chalk with *Inoceramus labiatus*, anterior probably to that with *Terebratella Bourgeoisii*, but at all events of Turonian age.

6. The above-named crumplings doubtless acted on other parts of the basin besides those named, but it was especially after the deposition of the Chalk with *Micraster cor-anguinum* and before that of the Chalk with *Belemnitella*, that the S.E.-N.W. elevations of the Seine, of Bray, Bresle, and Artois were clearly defined.

7. The S.W.-N.E. fold of Pressagny-l'Orgueilleux to Breteuil, also anterior to the Chalk with *Belemnitella*, was coincident with an upheaval of N.W. France, and the formation in the north-east, in Flanders, of a channel, apparently the only one, connecting the Paris Basin with the North Sea.

8. Finally, between the periods of the Chalk with *Belemnitella mucronata*, and the Pisolitic Chalk, an increase of elevation took place in the S.W.-N.E. axes of Bray and the Seine.

The lateral pressures which have caused these two systems of folds seem generally to have acted alternately, and so far from having formed them at once, appear to have acted through successive epochs. The S.W.-N.E. system showed itself first; but as far as the actual configuration of the ground is concerned, the S.E.-N.W. series exercised the more considerable influence, inasmuch as its action was prolonged to the close of the Tertiary deposits of the Paris Basin, destroying or at least obliterating the effects of the perpendicular folding.

II.—ON A RECENT DISCOVERY OF CARBONIFEROUS BATRACHIANS IN NOVA SCOTIA. By J. W. DAWSON, LL.D., F.R.S. (American Journal of Science and Arts, vol. xii., Dec. 1876.)

THE erect Sigillariæ inclosed in the sandstone overlying coal-group 15 of Section XV. Division 4, of the South Joggins section, have already furnished Principal Dawson with numerous remains of the reptilia of the Coal Period. The contents of another of these hollow stems have recently been investigated by him with great success.

Thirteen skeletons, representing six species, were brought to light, besides several Millipedes and shells of *Pupa vetusta*. These remains enable Prof. Dawson to give fuller descriptions than hitherto of the genera *Hylerpeton*, *Dendrerpeton*, and *Hylonomus*, and to add two new species to the first-named genus, viz.—*Hylerpeton longidentatus*, and *H. curtidentatus*.

REVIEWS.

The Primæval World of Switzerland: with 500 Illustrations. By Professor Oswald Heer, of the University of Zurich. Edited by James Heywood, M.A., F.R.S. (Translated by W. S. Dallas, F.L.S., Assistant Secretary Geol. Soc. Lond.) Illustrated by a coloured Geological Map of Switzerland; 7 tinted page-size plates of scenery; and 11 Plates of Fossils. 2 vols. 8vo. pp. 716. (London, Longmans, Green & Co., 1876.)

THE physical features of Switzerland have long been nearly as familiar to a large portion of our countrymen as the hills and valleys of their native land. Each mountain peak, each pass and glacier, has been visited and graphically described.[1]

Elijah Walton has painted for us the rosy-tinted Matterhorn, the pale Mont Blanc, and the blushing Jungfrau kissed by the first rays of the rising sun.

Forbes, Ball, Tyndall, Wills, Whymper, and numerous leading members of our Alpine Club have scaled its peaks and studied its glaciers, and probably nearly as many papers on the geology of the Swiss Alps have been written by English as by Swiss geologists. Foremost in the ranks of the latter stands the author of the present work, Dr. Oswald Heer, of Zurich. Already well known abroad as the author of many valuable works on Fossil Botany and Entomology,[2] he has given us the benefit of his services here also in the examination and determination of the plant-remains from the series of lignites and clays of Bovey Tracey, Devonshire,[3] and from the Norfolk Forest-bed; whilst to him also we are indebted for that wonderful chapter in Fossil Botany revealed by the Plant-beds of Greenland and Spitzbergen, whose treasures have been brought back by Nordenskiöld and others, and placed in Dr. Oswald Heer's hands for description.

Under the title of "Urwelt der Schweiz," the present work appeared at Zurich in 1865, and a French edition, in 1872, was published at Basle and Geneva.

Perhaps the most attractive feature of the work before us is a series of eight tinted plates, giving ideal views of Swiss land and sea in the Carboniferous, Keuper, Lias, Jura, the Miocene, Quaternary and Glacial Periods.

If we ventured to criticize these restorations, we would take exception to the foliage of *Lepidodendron* in the Carboniferous Period being represented as pendulous, like the Weeping-willow. From an examination of numerous remains from the Coal-measures, we are satisfied that the leaves and cones were borne erect, not depending. We think the same criticism applies to the '*Asterophyllites*' foliage of the Calamites, which would not, we venture to suggest, have bent downwards, but have turned upwards also. The dear old *Stigmaria, without a Sigillaria stem*, is growing in the water, as in the early days of geological inquiry.

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[1] See the Alpine Guides by John Ball, F.R.S., late President of the Alpine Club, London, Longmans & Co., in 10 parts at 2*s.* 6*d.* each, with excellent maps and panoramas.

[2] On the Tertiary Flora of Switzerland. On the Vegetation and Climate of the Tertiary Period. On the Tertiary Insects of Œningen and Radoboj.

[3] The Lignite Formation of Bovey Tracey, by W. Pengelly, F.R.S., and Dr. Oswald Heer, of Zurich, Phil. Trans., 1863.

In order to account for a Carboniferous fauna and flora in high northern latitudes, Dr. Heer advocates the theory that at that time the preponderant heat on the earth was *not that of the sun.* It is, however, a generally-received doctrine among geologists and physicists at the present day, that the influence of the earth's internal heat had ceased to affect the climate of the globe long before either its crust, its waters, or its atmosphere had become sufficiently modified to admit of their becoming the abodes of living organisms. Any appeal, therefore, to the internal heat of the earth in explanation of abundant animal and plant life in high Arctic regions, either in Palæozoic or Neozoic times, must be deemed unsatisfactory at the present day; and the key to the solution of the problem must be sought either in a change in the inclination of the earth's axis, an increase of the sun's heat, or probably in a combination of these causes together with a complete change in the relative distribution of land and sea in both hemispheres. Prof. Heer seems to regard the absence of light during the long Arctic winter as unimportant, provided the heat was only maintained well above freezing-point. Even the insects of the Coal Period he believes to have been chiefly nocturnal. But there were many diurnal insects present in the Coal Period besides the nocturnal *Termites* and Cock-roaches.[1]

The accompanying figure is (together with others), by the courtesy of Mr. Heywood, reproduced from Prof. Heer's work.

FIG. 1.

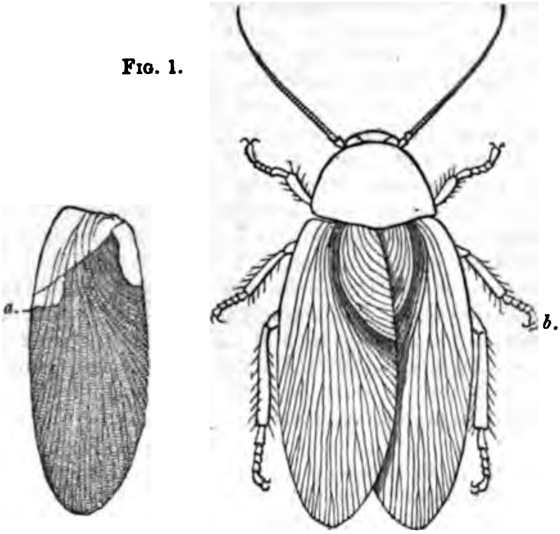

FIG. 1. *Blatta helvetica*, Heer, Coal-measures, Erbignon.
a. Wing of the natural size. *b.* The entire insect (restored by Heer).

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[1] See Quart. Journ. Geol. Soc. 1876, vol. xxxii. pp. 60–64, pl. ix.; and GEOL. MAG. 1876, Decade II. Vol. III. pp. 519–520.

Prof. Heer describes and figures many of those beautiful Carboniferous plant-remains coated as it were with silver or gold, met with in the Valais and higher up in the Col de Balme. These plants have also been found at the Col d'Anterne above Chamouni, and were examined in 1856, by Mr. Alfred Wills, whose collection is preserved in the British Museum. One remarkable feature to be seen at the village of Petit Cœur, near Moutiers in the Tarentaise (due to the inversion of the Carboniferous strata), was noticed by Élie de Beaumont in the 'Annales des Sciences Naturelles' so long ago as 1828.[1] Here we find *Belemnites* in Secondary rocks *beneath* shales of undoubted Carboniferous age.[2]

From the formation of Coal, Prof. Heer proceeds to speak of that most nearly analogous accumulation of vegetable fuel—*Peat*, which we may observe going on at the present day over such extensive tracts in the colder temperate regions of the earth, and from which, in Denmark, Ireland, Switzerland, and some parts of England also, such interesting relics of prehistoric man have been obtained.

Unfortunately for Switzerland, her industrious and patriotic people enjoy but a very small share of that valuable Coal-formation so widely distributed through England, Belgium, and the United States. Consequently peat and wood fuel are carefully collected and stored, and for coal its industries depend upon the basins of Saarbrück and St.-Etienne and a smaller quantity from the Vosges (Bonchamp), and from the Ruhr district in Westphalia. The rate of growth of peat is no doubt subject to considerable climatal variations, being readily influenced both by the temperature and moisture of the atmosphere. Prof. Heer says that—"Under moderately favourable circumstances, 1 foot of peat may be produced in a century. In the form of coal this would make a layer of 0·33 line, or about ⅓rd of a line. To produce a bed of coal 44 feet in thickness, such as occurs in England, a period of nearly 20,000 years would therefore be necessary. If we take the increase at 3 lines annually, 10,000 years would be required, or with 4 times the increase, only 5,000 years."

Even under the most favourable conditions for rapid increase, however, the period of time involved in the annual growth, decay and accumulation of vegetation and its conversion into coal, must necessarily have been immense. In South Wales, for instance, the total thickness of the Coal-measures has been reckoned at from 10,000 to 12,000 feet. Estimating the increase of sediment at 2 feet in a century, and admitting, with Mr. C. Maclaren, that it might take 1000 years to form a bed of coal 1 yard in thickness, Prof. Hull has calculated that the deposits forming the South Wales Coal-field might have been accumulated in 640,000 years![3]

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[1] See also Sir C. F. Bunbury's paper on Fossil Plants from the Anthracite Formation of the Alps of Savoy, Quart. Journ. Geol. Soc. Lond., 1849, vol. v. p. 130.

[2] See Prof. Favre's Geological Researches in the Vicinity of Mont Blanc in Savoy, Piedmont, and Switzerland, vol. iii. p. 337, etc.

[3] See "The Geology of England and Wales," by Horace B. Woodward, F.G.S., 1876, p. 93.

"In Switzerland no fossil remains of the Permian period have been preserved, although some of the Swiss rock-masses probably belong to this epoch." The Muschelkalk, with its salt-deposits, is met with on the left bank of the Rhine extending from Ryburg (near Rheinfelden) to Basle. Borings at Schweizerhall, between Basle and Augst, revealed a deposit of rock-salt 30 feet thick at depth of 420 feet. At Rheinfelden it is probably 60 feet in hickness.

At Salzburg and Berchtesgaden the salt is mined dry by means of umerous horizontal workings; but at Rheinfelden, Schweizerhall, ugst and Ryburg the wet method is adopted. Water is conducted hrough the salt and is then pumped out and evaporated; in this ay about 590,000 cwt. of salt are produced annually. Salt works lso exist at Bex in the Canton de Vaud.

Good figures of the characteristic fossils of the Muschelkalk, e.g. *eratites nodosus, Nautilus bidorsatus, Encrinus liliiformis, Pemphix ueurii*, etc., are given. This is the case with each formation described hroughout this work.

In the Keuper of Basle, we meet with those gigantic Horse-tails *Equisetum arenaceum*), which for size might fairly rival some of the *alamites* of the Coal Period. A very effective coloured plate, lustrative of the Flora of the Keuper period, with its Tree-ferns, *oltzias*, and *Equisetaceæ*, deserves to be specially noticed.

From the Keuper Period of Basle we pass to the Liassic formation f Schambelen in the Canton Aargau, and here, as also in the suceeding Jurassic Period, Prof. Heer unfolds before us the rich reasures of the sea with its *Ammonites*, its *Pentacrinites*, its Star-shes and shells, its Shrimps and Lobsters and fishes with namelled scales.

The Lias is rich in fossil forms, but the Jura is even richer still; r besides abundance of marine organisms, we have a most teresting revelation of the contemporary terrestrial fauna and ora preserved to us. The Swiss in his inland valley is far from he shores of the ocean of to-day, yet he resides in a vast marine ay left dry by the retiring waters; and the rocky walls around him ere once great Coral-reefs, within whose shelter lived and died ishes and Mollusca, Echinoderms and Crustacea without number, nd upon whose dry and higher island summits once grew the amia and the Palm-tree, whilst, fearless of aldermen, the Turtles nd the Lizards laid their eggs or rested peacefully upon its beaches.

If then it be a pleasure to wander along the sea-coast, gathering e productions of the sea left at our feet by the retiring tide, how reat must be our interest and surprise as we wander among the wiss mountains to gather the relics of the fauna of the sea-shores a primæval world!

But the geologist can do more than this; for without dredge or iver's aid he can study each zone of life in this ancient sea from its ore-line with Patellas and Purpuras, Neritas and Mytili, down to e 100-fathom line, each depth marked by its special residents, its

Bivalves and Gasteropods, its Corals, Sponges, Sea-urchins, and *Pentacrinites*, down, down to the *Globigerina* ooze.

An interesting feature of the work is the introduction of a series of maps giving in outline the probable relations of sea and land in Jurassic, Cretaceous, and Miocene times in Central Europe.

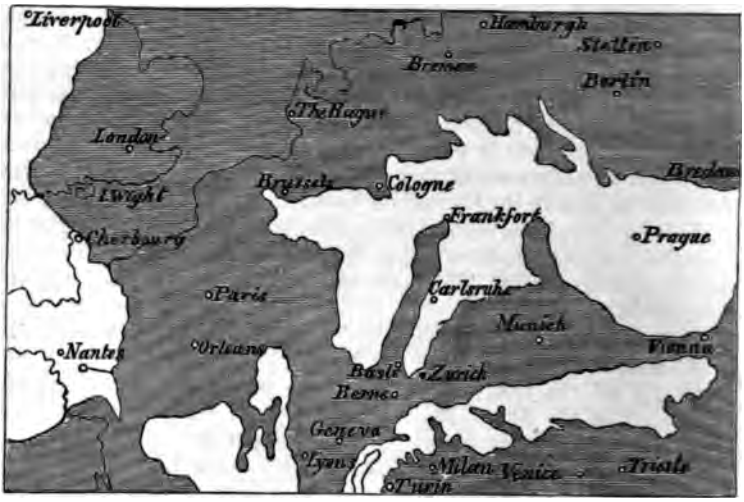

FIG. 2. Central Europe in the Jurassic Period. The continents are white; the shaded parts represent the sea. (Fig. 97, p. 168, Heer.)

Undoubtedly the most wonderful record of the life-history of the Jurassic Period has been preserved to us in those remarkable quarries in the Lithographic Stone of Eichstadt, Pappenheim and Solenhofen, near Munich in Bavaria.

Here comparatively thin-bedded limestones are exposed, which have evidently resulted from a long-continued supply of extremely fine and homogeneous mud derived from the disintegration of adjacent land by some great river system bringing down vast quantities of wasted Magnesian and more recent Rhætic limestones, whose commingled sediments, especially in their thinner and probably more shoal-water depositions, reveal to us the near presence of land teeming with life, as attested by large Dragon-flies, Beetles, Hemipterous insects, long and short-tailed Pterodactyls and Land-lizards, and that remarkable bird the *Archæopteryx*.[1] Numerous *Coniferæ* are evidenced by detached branches and remains of cones, some of which have been described by Prof. Dyer in the pages of this MAGAZINE.[2] These, with abundance of Fishes. Crustacea, and Mollusca, make up a marvellously rich record of Upper Jurassic life; and the geologist who would understand the Jura Period thoroughly should pay these classical quarries a visit on his journey to or from Munich, where, in the National Museum, he will find a magnificent collection of the type specimens of von Meyer's, Schlotheim's, Oppel's, Zittel's, and many other celebrated palæontologists' figures and descriptions of Lithographic limestone fossils.

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[1] Preserved in the British Museum, and described by Prof. Owen in the Phil. Trans. 1863, p. 33, pl. 1.

[2] See paper on some Coniferous Remains from the Lithographic Stone of Solenhofen, by Prof. W. T. Thiselton Dyer, B.A., B.Sc., F.L.S., GEOL. MAG. 1872, Vol. IX. pp. 150, 193, Pl. V., etc.

"During the succeeding Cretaceous Period, a great part of Switzerland was dry land, the sea covering chiefly the low ground from the Lake of Constance to the Lake of Geneva; its northern coast ran nearly in the direction of Schaffhausen by Aarau and Soleure to Bienne, and thence extended further westward, quitting the limits of Switzerland. The sea no doubt covered these districts, where strips of marine Cretaceous deposits are frequently met with, which were formerly connected together. The southern shore of the Swiss Cretaceous sea is shown generally by a line drawn from the Lake of Wallenstadt to Altdorf, the Lake of Brienz and Bex; but there are numerous and deep inlets bringing the sea into the interior of the Alps, as in the Canton of the Grisons, where the Calanda and part of the chain of the Kalfeusen are formed of Cretaceous rocks." (p. 176.)

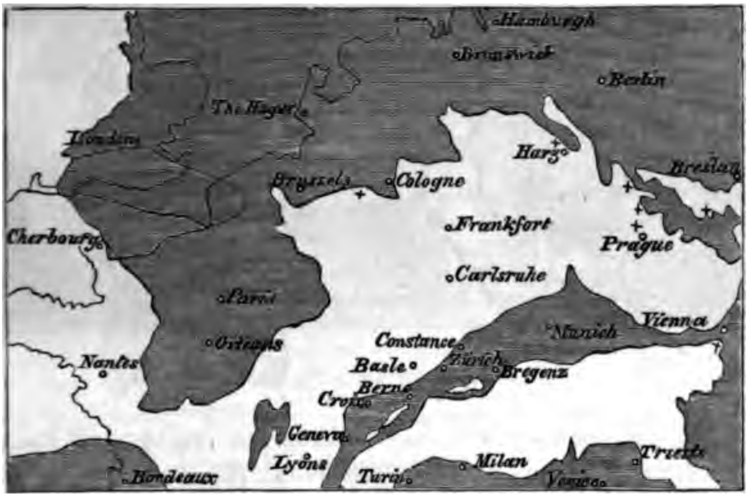


FIG. 3. Central Europe during the Cretaceous Period. The white portions represent continents; and the shaded parts are seas. (Fig. 98, p. 175, Heer.)

Passing from the Cretaceous formation to the Tertiary Period, we have in the Eocene slate-quarries of Matt, in the Canton Glaris, the most important Swiss locality for the remains of fossil fishes. Dry land was at no great distance, as evidenced by the fossil remains of two species of birds found at Matt. These beds must have undergone great pressure, as they closely resemble the Cambrian slates of Bangor in their general appearance, though of a much darker hue; they are also largely quarried *for the* same economic purposes as our

Palæozoic slates. A fine series of fish remains from these beds may be seen in the Geological Collection of the British Museum.

No fewer than fifty-three species of fish have been identified and described, together with two Sea-turtles and two Birds. We subjoin a figure of one of the turtles.

FIG. 4.

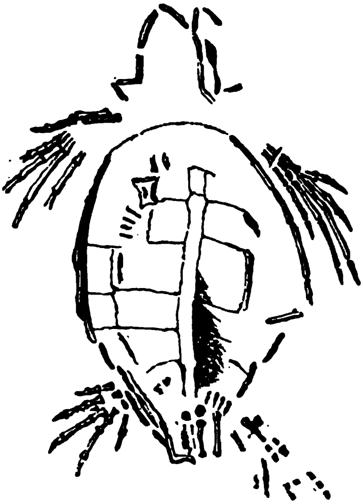


FIG. 5.

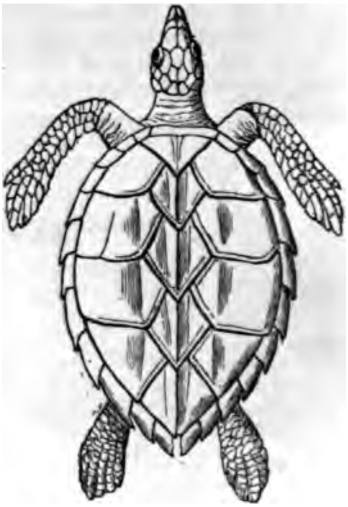


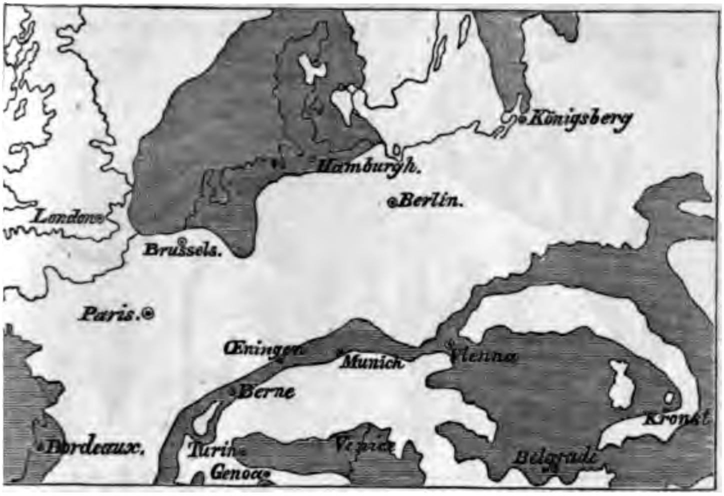
FIG. 4. *Chelone ovata*, Heer, from Matt, one-third nat. size. (Fig. 141, p. 248, Heer.)

FIG. 5. *Chelone imbricata*, living Hawk's-bill Turtle. (Fig. 142, p. 248, Heer.)

The birds (*Protornis Blumeri*, Heer, and *P. glaronensis*, Meyer) were about the size of Larks, and appear to have belonged to the family of Finches.

The Glaris slate-rock is the oldest of these Swiss Tertiary deposits. and, like the beds of Monte Bolca, is of Middle Eocene age. Above it is the Nummulitic formation of Ralligstöcke, and the newest, the shales of Mauremont, Soleure, and Obergösgen, containing remains of no fewer than twenty-five genera of terrestrial Mammalia, together with twelve Reptilia represented by Cheloniæ, Ophidia, and Crocodilia.

Nearly one-fifth of the area of Switzerland (about 152 square geographical miles), comprising the lowland, undulating country between the Jura and the Alps, is covered by masses of marls and sandstones, which have received the general name of "Molasse," and include all the formations of Middle Tertiary or Miocene age in this area. These deposits are of great thickness, and rise on the borders of the Alps into considerable mountains, such as the Speer (6021 feet) and the Righi (5541 feet). To the south the 'Molasse' is stopped by the zone of 'Flysch' and the Nummulitic deposits; it touches the Cretaceous rocks only in a few localities. To the north t is bounded by the Jura, and by the heights of the Cretaceous ocks belonging to that chain.



. 5. **Central Europe in the Middle Miocene Period (the Helvetian stage). The continents are white; and the shaded parts represent the sea. (Fig. 154, p. 296, Heer.)**

The following are the divisions recognized by Prof. Heer :—

Upper Miocene.	**Upper Freshwater Molasse.** **V. Upper Brown Coal-formation.** ***Œningian Stage.***
Middle Miocene.	**Marine Molasse.** **IV. Helvetian Stage.** ***Subalpine Molasse.*** ***Shell Sandstone.***
Lower Miocene.	**Lower Freshwater Molasse.** **III. Grey Molasse Stage.** **II. Lower Brown Coal-formation.** ***Aquitanian Stage.*** ***Red Molasse.*** **Marine Molasse.** **I. Tongrian Stage.**

"Switzerland takes the lead of all countries in its abundant posits of Miocene plants. There are about eighty places in vitzerland where Miocene plants have been collected." Of these onod has yielded 193 species; Locle, 140 species; Hohe-Rhonen, :2 species; and Œningen, 465 species; 920 species of Miocene ants are known to Heer from various Swiss localities.

There can be little doubt that forests covered Switzerland in the iocene Period probably similar in character to those which clothe e valleys of the Orinoco and the Amazon in South America at the esent day.

Cupressineæ and *Abietineæ* are the two chief Coniferous families hich during this period composed so large a proportion of the rest flora all over Europe.

FIG. 6. FIG. 7. FIG. 8.

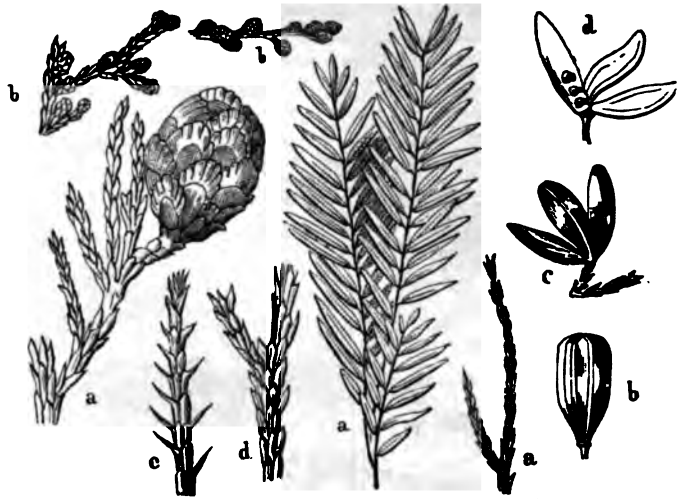


FIG. 6. FIG. 7. FIG. 8.

FIG. 6. *Glyptostrobus europæus*, Br. sp. Œningen. *a.* Branch with a mature cone: *b.* twig with male flowers; *c.* twig with divergent leaves; *d.* twig with adpressed leaves.—FIG. 7. *Taxodium distichum miocenum.* *a.* From Hohe-Rhonen; *b.* male flowers from Bilin.—FIG. 8. *Widdringtonia Helvetica*, Heer, from Hohe-Rhonen. *a.* Branch; *b.* closed cone; *c.* cone open; *d.* open cone with seeds. (Heer, Figs. 155, 156, and 158, p. 324.)

The genus *Sequoia* had a wide distribution in Tertiary times from Central Italy and Greece up to the Arctic zone.

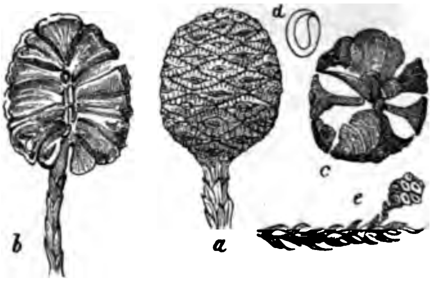


FIG. 9. *Sequoia Langsdorfi.* *a.* cone from Rixhöft; *b.* longitudinal section with seed; *c.* transverse section; *d.* seed; *e.* female flowers. From Greenland, 70° N. lat. (Heer, Fig. 158B, p. 329.)

Sequoia Langsdorfi is found fossil on the Mackenzie River, in Greenland, in Kamtschatka, in Alaska, and also in many European localities. This form is closely related to the redwood (*Sequoia sempervirens*) which forms great forests at the present day in the coast-range of California, throwing up stems 250 feet high. The Mammoth-tree (*Sequoia gigantea*) is found only in the higher Sierra, and is much more limited in its range than the other species, and is probably dying out, other and smaller Coniferæ apparently far out-numbering it upon its own ground.[1] It attains a height of 300–320 feet, and a diameter of 20–30 feet. Remains of this genus are found in the

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[1] See the admirable Address by Prof. Asa Gray to the American Association at *Dubuque, Iowa, in Silliman's* American Journal, 1872, 3rd series, vol. iv. p. 282.

Brown-coal of Bonn and in the Miocene Lignites of Bovey Tracey, and its ancestry has been traced back as far as the Cretaceous Period.

At least twelve species of Palms have been met with in Swiss Miocene deposits.

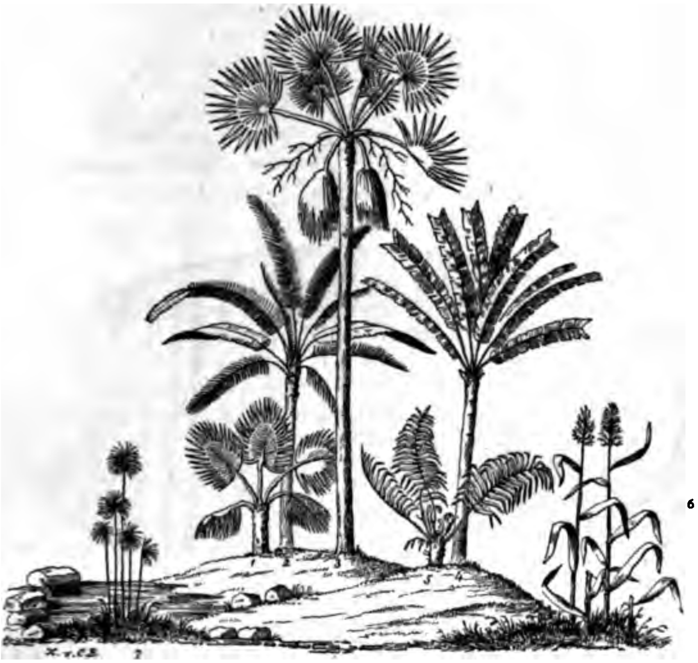


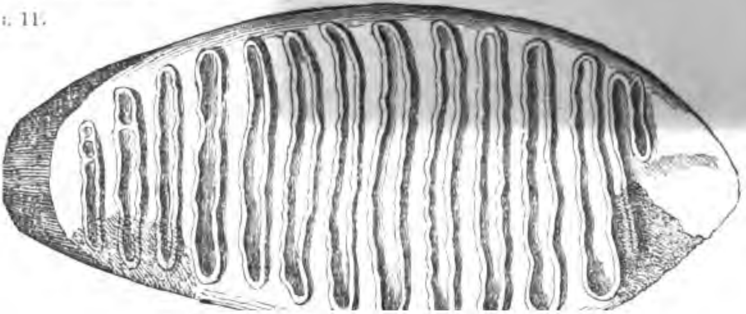
FIG. 10. Palms, etc. of Switzerland, restored from their leaves. 1. *Sabal major*, Ung. sp. 2. *Phenicites spectabilis*, Ung. 3. *Flabellaria Ruminiana*, Heer. 4. *Manicaria formosa*, Heer. 5. *Lastræa stiriaca*, Ung. sp. 6. *Phragmites Œningensis*, A. Br. 7. *Cyperus vetustus*, Heer. (Fig. 164, p. 335, Heer.)

Bearing in mind that only a single species of palm, the dwarf Fan-palm, *Chamærops humilis*, Linn., is now found in Europe, we may conclude that a more warm and equable climate was enjoyed over all this region of the earth.

"This higher temperature of the Swiss Miocene land may be in part explained by the form of Europe at that time. A different distribution of land and water is seen in the map of Central Europe at this period (see Fig. 5). The eastern sea, which extended into Switzerland, must have exerted a warming influence, as it was connected with the Indian Ocean through the Red Sea, and perhaps also through the Persian Gulf. From this tropical sea, a current of warm water, like the existing Gulf-stream in the Atlantic, flowed towards the northern seas, exerting a powerful influence upon the temperature of the surrounding lands by means of the broad arms of the sea, which penetrated into the heart of Europe." (vol. ii. p. 263.)

Like the plant-life, Insects were most abundant at Œningen, about 876 species having been described. Fishes of freshwater species were also plentiful, together with gigantic Salamanders, Frogs, Toads, Lizards, Crocodiles, Serpents, and Tortoises, in all 27 species; and six species of Birds; whilst of Mammalia 59 species are known, 3 genera only of which now occur in Switzerland (*Cervus*, *Sus*, and *Sciurus*). The Gibbons now live in India; the Opossums (*Didelphys*) in South America; the Rhinoceros and Musk-deer in India and Africa; the Tapirs in India and S. America. Space does not permit us to complete this interesting historical sketch of Middle Europe down to the present day. A long lapse of centuries follows filled up by the Quaternary Period with its more sombre forests of Pines, Birch, Oak, and Sycamore, its herds of wild Elephants, its Rhinoceroses and Buffalos.

i. 11.



With this piling up of the drift over these last records a period was reached when Man appeared on the scene. Then came the Pile-builders, and constructed their villages in the Swiss lakes, the history of which has been so admirably told for us by Keller, and translated by Mr. J. E. Lee, F.S.A. But of all this, and of the Glacial Period in the Swiss valleys when the Alpine flora and fauna came down the mountain sides into the sheltered valleys, and ice and snow increased greatly, let those who desire to know more, read Prof. Heer's interesting volumes.

To the lover of Switzerland an additional charm will be added to each fresh visit by this insight into its ancient history teeming with matter of interest alike for the palæontological and geological student. H. W.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.—I.—December 20th, 1876.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.

The President read to the Meeting a copy of resolutions passed at the Meeting of the Council of the Royal Society held on December 7th, relative to the administration of the Government Fund of £4000, voted for the advancement of Scientific Research. He stated that the Secretaries of the Royal Society were prepared to receive applications for a portion of the sum so liberally voted by Government for the advancement of science, and added that the Council of the Geological Society would be glad to receive any hints or suggestions bearing upon the disposal of this fund.

The President also announced that the late Dr. Barlow, whose loss must be deplored by all the Fellows of the Society, had left to the Society by will the sum of £500, to be invested and to constitute a Fund under the title of the "Jameson-Barlow Fund," the proceeds to be applied annually, or at intervals of two or more years, at the discretion of the Council, in such manner as shall seem to them best for the advancement of the study of Geology. Dr. Barlow also left to the Society, under certain restrictions, his Collections of geological specimens, and a selection of books from his Library.

The President further announced the donation to the Society by the Earl of Enniskillen of the drawings made by Mr. Dinkel, from Sir Philip de Malpas Grey-Egerton's collection, for the illustration of Prof. Agassiz's great work on Fossil Fishes, presented in accordance with the promise made by his Lordship at the meeting of the 24th May.

The following communications were read:—

1. On "*Pharetrospongia Strahani*, a fossil Holorhaphidote Sponge from the Cambridge Coprolite Bed." By W. J. Sollas, Esq., B.A., F.G.S.

The sponge described by the author, which had been long labelled as a *Chenendopora* in the Woodwardian Museum at Cambridge, is a fossilized siliceous sponge, characterized by an irregularly reticulate fibrous skeleton, the fibres of which in the living state were composed of a number of *siliceous acerate* spicules, lying parallel to each other and to the sides of the fibre. These spicules are still sufficiently well preserved to be figured and measured individually, though they have undergone a pseudomorphic change, by which their original composition has been exchanged for a calcareous one. A similar replacement has occurred in the case of various species of *Manon* and *Porospongia*; and this fact is of great interest, as showing that the extinct and anomalous order of Calcispongiæ, which these fossils were supposed to indicate, has no necessary existence, since their calcareous nature is a superimposed one, and their original structure agrees completely with that of existing siliceous forms. *Pharetrospongia Strahani* itself exhibits close affinities to an undescribed sponge now living in the Australian seas.

2. "On the remains of a large Crustacean, probably indicative of a new species of *Eurypterus*, or allied genus (*Eurypterus? Stevensoni*) from the Lower Carboniferous series (Cement-stone group) of Berwickshire." By Robert Etheridge, jun., Esq., F.G.S., Palæontologist to the Geological Survey of Scotland.

The fragmentary Crustacean remains described in this paper are referred by the author to a large species of *Eurypterus*. They are from a rather lower horizon in the Lower Carboniferous than that from which *Eurypterus Scouleri*, Hibbert, was obtained. The animal was probably twice the size of *E. Scouleri*. The remains consist of large scale-like markings and marginal spines which once covered the surface and bordered the head and the hinder edges of the body-segments of a gigantic Crustacean, agreeing in general characters with the same parts in *E. Scouleri*, but differing in points of detail. For the species, supposing it to be distinct, the author proposes the name of *E. Stevensoni*.

Mr. H. Woodward remarked that the remains of *Eurypteri* from the Carboniferous rocks are so distinct from the Upper Silurian *Eurypteri* of America, Shropshire, Lanarkshire, and Russia, as probably to entitle them to be placed in a distinct genus; and, indeed, at some future day, when more remains are obtained, they may perhaps have to be arranged among the Arachnida, along with many curious fragments which have been called *Arthropleura*, discovered by Mr. M'Murtrie in the Radstock Coal-field, by Mr. Jordan in the Saarbrück Coal-basin, and by Mr. Gibbs in the Manchester Coal-field. *Eurypterus Scouleri* occurs at Kirton with *Sphenopteris Hibberti* in a remarkable siliceous deposit, probably thrown down by an old thermal spring in the Carboniferous period.

Prof. Ramsay remarked that the rock from which the fossils were derived seemed to him to be pretty nearly the equivalent of the Burdie-House Limestone, which he had long ago thought might be to a considerable extent formed by calcareous deposits from thermal waters, probably during a period of great volcanic activity. This would be in favour of Mr. Woodward's opinion.

3. "On the Silurian Grits near Corwen, North Wales." By Prof. T. McKenny Hughes, M.A., F.G.S.

The author commenced with a description of sections near Corwen, in North Wales, from which he made out that the grits close to Corwen were not the Denbigh grits, but a lower variable series, passing in places into conglomerate and sandstone with subordinate limestone and shale. This series, under the name of '*The Corwen Beds*,' he described in detail, having traced them round the hills S. of Corwen, also near Bryngorlan, S. of the Vale of Clwyd, on Cyrnybrain, and S. of Llangollen. He had noticed in places a kind of double cleavage affecting the lower series, but not the upper, and also fragments of cleaved mudstone included in the upper, from which he inferred a disturbance of the older rocks previous to the deposition of the newer. He exhibited a selection of fossils, and said that immediately below the Corwen beds there were none but Bala fossils. In the Corwen beds all the few fossils found were common to the Llandovery rocks, some of them, as *Meristella crassa* and *Petraia crenulata*, being peculiar to that formation. In the flaggy slates above the Pale Slates he had found Graptolites and Orthoceratites of the same species as those found in the Denbigh Flags. He considered that the Corwen Beds were on the horizon of the May Hill or Llandovery group, and should be taken as the base of the Silurian, thus including in the Pale Slates or Tarannon Shale a thick series which intervened between the Corwen Beds and the flaggy slates of Penyglog.

4. "On Mineral Veins." By W. Morgan, Esq. Communicated by Warington W. Smyth, Esq., F.R.S., F.G.S.

The author maintained that no one theory can be accepted in explanation of the formation of mineral veins; and that whilst in some cases their formation may be due to the presence of pre-existent fissures induced by shifting of the containing rock, in others any such explanation is insufficient, as he thought the means by which the sides of such fissures were kept apart could not be easily indicated. The point upon which he especially insisted in connexion with this question was the presence of "horses" in many mineral veins. He advocated the view that the walls of veins were in close proximity in their earliest stage, and that the enlargement and infilling of the veins took place simultaneously by the segregation of materials derived from the adjacent rock, supplemented, perhaps, by a tension or tendency to separation caused by slow contraction of the latter. Instead of a fissure he assumed the presence of an irregular surface of least resistance or of electrical action, at which the vein matter might collect at first as a mere film. In this way, he thought, the vein might increase and its walls might recede simply by the aggregation of the vein-matter itself, and in general in proportion to the degree of mineral saturation of the adjacent rocks.

II.—January 10th, 1877.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.—The following communications were read:—

1. "On Gigantic Land-Tortoises and a small Freshwater Species from the Ossiferous Caverns of Malta, together with a List of the Fossil Fauna, and a Note on Chelonian Remains from the Rock-cavities of Gibraltar." By A. Leith Adams, Esq., M.B., F.R.S., F.G.S., Professor of Zoology in the Royal College of Science, Dublin.

The author described three extinct species of Tortoises from the Maltese rock-cavities, one of which was of gigantic proportions, and equalled in size any of the living or extinct land Chelonians from the Indian or Pacific islands. The characteristic peculiarity in the two larger species is a greater robustness of the long bones as compared with the denizens of the Mascarene and Galapagos islands, with which he had been enabled to contrast them. The largest, on that account, he had named *T. robusta;* it rivalled the gigantic *Testudo ephippium*, Günther, in size, showing affinities to it in a few minor characters. A smaller species, *T. Sprattii*, and a small *Lutremys*, not distinguishable, as far as the few remains extend, from the recent *L. europæa*, besides many fragments of shields of tortoises of various dimensions, had been obtained. These Chelonians were found in conjunction with the remains of the dwarf Elephants and other members of the remarkable fauna, collected by Admiral Spratt and the author in the ossiferous rock-cavities of Zebbug, Mnaidra, Benghisa, etc. The paper contained a list of the animal remains hitherto recorded from the Maltese fissure caverns, including three species of dwarf Elephants, two species of *Hippopotamus*, two gigantic species of *Myoxus*, a gigantic Swan, and other animal remains; and further, a Note on some Chelonian remains from the rock fissures of Gibraltar.

2. "On the Corallian Rocks of England." By the Rev. J. F. Blake, M.A., F.G.S., and W. H. Hudleston, Esq., M.A., F.G.S.

The object of the paper was to describe the rock masses existing betwixt the Oxford and Kimmeridge Clays. Topographically the Corallian region is divided into five districts of very unequal size, wholly separated from each other. The special features of each district were detailed, both as regards the development, composition, and fauna of the several subformations therein contained, and these latter compared with their equivalents or representatives in the other districts. The old names were, as far as possible, retained; but, where obviously inapplicable, local names replaced them.

In the Weymouth district (I.) one section discloses 230 feet of beds between the Oxford and Kimmeridge Clays, made up in ascending order of grits, clays, marls and oolites, gritty limestones very fossiliferous towards the top, clays, and grits. Another section on the opposite side of the anticlinal shows the same development of the central limestones; but the lower series is considerably attenuated, and the upper series (Supra-Coralline) shrunk from about 90 feet to a thin ferruginous band of only a few inches. There are hardly any corals, and no Coral Rag whatever; argillaceous and arenaceous matter, always, however, more or less mixed with lime, preponderates, but there is a rich and varied fauna, which has strong affinities with some of the Corallian beds of other districts. This culminates in the *Trigonia*-beds, which lie towards the top of the main limestone series; above this the fauna inclines to Kimmeridgian, below to Oxfordian types. The remarkable irregularity of the Supra-Coralline beds was noted, especial reference being made to the mineral character, fossil contents, and geological position of the Abbotsbury iron-ore. In the North Dorset district (II.) the thickness of the mass is much reduced, and its constitution greatly altered. Corals are still very rare, but calcareous sediment greatly preponderates, and is made up largely of comminuted shell, loosely aggregated pisolites, and rubble, frequently false-bedded; the arenaceous base of the Corallian series, described generally under the term Lower Calcareous Grit, is almost at its minimum in the neighbourhood of Sturminster. The central limestones contain a moderate assemblage of the usual Corallian forms, but *Cidaris florigemma* appears confined to a rubbly bed of about 8 feet thick. The West Midland range (III.), extending from Westbury to Oxford, exhibits the greatest variety, and, being classic ground, contains a larger proportion of the type forms of the rocks. The development is very unequal, and the entire group is reduced to less than 25 feet in some places; but where the sandy base is expanded, as in those districts where the escarpment faces the north, the thickness exceeds 100 feet, occasionally falling to about 30 feet in the direction of the dip, with the probability of the entire mass ultimately thinning to a feather edge. In many places true Coral Rag is largely developed, usually terminating the Corallian series in an upward direction, or at most succeeded by a very few feet of ferruginous sand. Throughout the great escarpment facing the upper valley of the Thames, the lower arenaceous member predominates, though much mixed with thin-bedded sandy clays, the whole constituting a loose formation, which is capped by hard gritty limestone containing an abundant fauna, representative of the middle series, differing somewhat, on the one hand, from the Rag with its partially Kimmeridgian character, and, on the other, from the Lower Calcareous Grit, whose affinities are, of course, Oxfordian. The beds of this district, however, are so varied that it is impossible to deal with them in an abstract. District IV. includes the Coral reef at Upware, 75 miles E.N.E of Oxford; though the exposures are small, they are very suggestive. The limestone of the south pit is an excellent Coral Rag, but softer and more chalky than much of the Coral Rag of the West Midland district. Moreover, whilst the rock contains many familiar forms, and especially *Cidaris florigemma*, whose presence in abundance invariably indicates a distinct horizon, we also find the casts of shells, rarely or never met with in the West of England, but which appear common in some parts of the Continent: *e.g.* species of *Isoarca*, and certain species of *Opis*, which latter occur also in a portion of the Yorkshire Basin (V.). This bears 130 miles N. by W. from the reef at Upware. The Corallian beds are grouped as a belt of rocks inclosing an oval tract of Kimmeridge Clay. There is more symmetry here than in the south, and the triple division of grit, limestone, and grit, though not absolutely true in all places, is fairly accurate; most of the beds are better developed, and the contrast between the Coral Rag and underlying Oolites is strongly marked. In the Tabular Hills these Oolites constitute a double series, divided by a "Middle Calc Grit," a fact first indicated on stratigraphical grounds by Mr. Fox Strangways, and amply borne out by fossil contents. The shell beds of the Lower Limestones are, especially in their lower parts, charged with Brachiopoda and other forms of the Lower Calc Grit; whilst the Upper Oolite, on which the Coral Rag reposes, contains a far more varied fauna, though singularly destitute of Brachiopoda. The fauna of the Rag here, as elsewhere, inclines to Kimmeridgian types.

As the object of the paper was to arrange facts rather than to propound theories, the conclusion was chiefly occupied in summing up and correlating. It was shown that, since the leading feature of the rock masses between the Oxford and Kimmeridge Clays is *variety*, a strict and rigid correlation is altogether impossible. Yet, in spite of great local differences, producing in many places a strongly contrasted facies, there are certain features which may be deemed fairly characteristic of the several divisions. The bank-like character of most of these beds was insisted upon. A table of comparative sections, 14 in number, affording a generalized idea of the development, was exhibited, and the stratigraphical verifications of many of these given, as sections drawn to scale, in the body of the paper.

CORRESPONDENCE.

ORIGIN OF LAKE-BASINS.

Sir,—In reading the correspondence and remarks on the origin of Lake-basins in the November Number of the Geological Magazine, it has occurred to me that the glacial origin of these basins may be explained without supposing the ice to have scooped them out of *solid* rocks such as we now see around them. I have been led to this idea by a study of the phenomena connected with the decomposition of rock *in sitû* in southern latitudes—Australia and Brazil. Similar facts may likewise be seen in South Carolina, Georgia, etc.

In these regions, which have never been glaciated, the surfaces over more or less extensive areas consist of quite soft decomposed rock, and mining operations have shown that this decomposition l-lake *barriers* is a continuation of that of the mounds, and not perinduced. In the above district most of the eskers occur at a stance from river-valleys; often where there are no streams of ter; and sometimes on the summits of hills. Their magnitude eaching 150 feet in height) in Shropshire; the breadth of the rriers, and the depth and size of the inclosed lakes (not to ention the frequent total absence of streams of water) clearly show at their forms were left by the agency that piled them up, or nuded them before their emergence from the sea. So far as I n aware, all English and Irish geologists believe that their rvilinear shape is not owing to atmospheric action. [See Mem. of ish Geol. Survey, 98, 99, 108, 109, 117, 118.]

In answer to Mr. Mellard Reade I have only to say that I do not gard the drifts in the neighbourhood of Liverpool as good repre- ntations of the *general* succession one may trace from Carlisle to urch Stretton in Shropshire. Long sea-coast and railway sections tween these places (over a distance of about 150 miles) show persistency in the relative positions of the three drifts, or of two them where only two are present. The clay left by the sea shing the sand and stones out of the Boulder-clay *would not form Boulder-clay somewhere else on the same horizon,* but would give e to such a stoneless clay as we frequently find imbedded in the eat middle sand and gravel formation.[1] D. Mackintosh.

THE TROPICAL FORESTS OF HAMPSHIRE.

Sir,—In Mr. Gardner's lecture "On the Tropical Forests of ampshire," in your January Number, he is reported as offering o suggestions in explanation of the occurrence of the remains a temperate climate flora intermingled with that of a tropical one the Lower Bagshot of Hampshire. One of these is an oscilla- on of climate which for a time left survivors of the previous flora ngering beside the new growth introduced by a change of climate, d the other the existence of a mean annual temperature which rmitted the growth of either class of vegetation side by side.

As I believe both suggestions to be remote from the truth, and as e first of them is contrary to the general evidence afforded by the imal remains of the Eocene period in England, which appear to e to offer the strongest evidence against the existence of a glacial imate in Europe during any part of that period, perhaps you will low me to offer what I believe to be the true explanation.

The remains upon which the determinations of this flora have en based are drifted, and not those of a bed *in situ* like the Coal-seams, and the whole of the Hampshire Eocene is connected with the delta of a great river which persisted throughout the accumulation of the various beds, which aggregate to upwards of 200 feet in thickness. This river evidently flowed from the west, through a district of which the low ground had a tropical climate; but like some tropical rivers of the present day, such as the Brahmaputra, the Megna, the Ganges, etc., it was probably fed by tributaries flowing from a mountain region supporting zones of vegetation of all kinds from the tropical to the Arctic, if during the Eocene period vegetation such as the present Arctic had come into existence, of which we have as yet no evidence. Torrential floods may have swept the remains of vegetation from the temperate zones of this region into tributaries that conveyed it into the main river before it was decayed or water-logged, where it became intermingled with the remains of vegetation which grew in the tropical low ground skirting the main stream, so that both sank together into the same mud and silt.

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[1] For full and accurate information concerning the Post-tertiary deposits of this untry I would recommend Mr. H. B. Woodward's Geology of England and ales. It is the only geological work in which an account of these deposits has en thoroughly brought up to the present state of discovery. Having gone over the eater part of the ground described in Mr. Woodward's work, and having pre- ously written a work called "Scenery of England and Wales," I may be pardoned r stating that it exhibits more evident signs of great labour and care than any ological book I have read.—D. M.

Assuming, therefore, that the determinations of these extra-tropical forms of vegetation are well founded, we have in the case in question no difficulty in discovering those elevated regions from which, in the way suggested, such forms may have come, for Mr. Judd, in describing (Quart. Journ. Geol. Soc., vol. xxx. p. 220) the ancient volcano of Mull, which lies about 400 miles N.N.W. of Hampshire, has shown that it was in full activity during the Eocene and Miocene periods, and possessed a dimension much exceeding that of Etna at the present day; and that, though from denudation and collapses, the greatest elevation to which any of its

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No. III.—MARCH, 1877.

ORIGINAL ARTICLES.

I.—Evidence Afforded by the Planet Mars on the Subject of Glacial Periods.

By Edward Carpenter, M.A., late Fellow of Trinity Hall, Cambridge.

HAVING read with much interest Mr. Murphy's papers in the Journal of the Geological Society for 1869 (p. 350) and for 1876 (p. 400), in which he maintains that at the time of maximum excentricity of the Earth's orbit that hemisphere would be glaciated which had its *winter* in aphelion, as against Mr. Croll, whose theory is that the glaciated hemisphere would be that which had its *summer* in aphelion: it has occurred to me that I have never seen, in this discussion, any reference to the case of the planet Mars.

It may be worth while, therefore, in case no one has done so before, to point out how remarkable a parallel may be drawn between the state of affairs on that planet and on the earth, and how remarkable a confirmation the relative dimensions of the snow-caps on that planet appear to give of Mr. Murphy's view of the matter.

The excentricity of the orbit of the planet Mars is, as is well known, considerably greater than that of the earth's orbit. It is given by Sir John Herschel, in his Outlines of Astronomy, as 0·0931125. Leverrier's estimate of the maximum excentricity of the earth's orbit, as quoted by Mr. Croll, is 0·07075. The excentricity of Mars' orbit is therefore somewhat greater than the maximum excentricity of that of the earth. Again, the inclination of the axis of Mars to the perpendicular to the plane of its orbit is 25° 51′, which in a similar way is somewhat greater than the inclination of the earth's axis to the plane of the ecliptic, which is 23° 27′ 24″. So that in both respects Mars offers a slight exaggeration of the conditions supposed to prevail in the case of the earth at the time under consideration. But these coincidences would be of no service to us, were they not supplemented by a third, most fortunate, coincidence. The axis of Mars, namely, is inclined at the present time towards one extremity of the axis of its orbit, and indeed towards the perihelion point; so that *as on the earth at the present time* the winter solstice of the Northern hemisphere coincides with perihelion, its summer solstice with aphelion, and the winter solstice of the Southern hemisphere coincides with aphelion, the summer solstice with perihelion. To show how nearly this is the case it will be sufficient to quote the lengths of the seasons. They are given as follows (from elements of the planet obtained by Maedler and Sir William Herschel) by Mr. Breen, of the Cambridge Observatory. For the Northern hemisphere :—

Spring (vernal equinox to summer solstice)...	191⅓	Mars' Days.
Summer	181	„ „
Harvest	149⅓	„ „
Winter	147	„ „

Thus we have on Mars at the present time all the conditions prevailing which the case under consideration requires—only exaggerated: the axial inclination is slightly greater, the excentricity is greater, and the year is longer, 687 of our days instead of 365. Yet the exaggeration, at any rate in the cases of the axial inclination and excentricity, is by no means so great as to destroy the comparison: on the contrary, it might be expected just to emphasize it. One more point before proceeding to actual observations of the polar snows of Mars ; the distribution of land and sea on that planet is far more *equable* than on the earth, indeed there is a remarkable symmetry or likeness between the two hemispheres ; at neither pole is there, apparently, an ocean of great extent, and, as is well known, land predominates largely over sea throughout, the two being in an estimated proportion of three or four to one. Thus, as far as we can at all judge, *geographical* causes of difference between the poles seem to be next to eliminated on Mars, and we are left to observe the results of the purely astronomical influences.

And they are remarkable. I am not, unfortunately, able at the present moment to lay my hand on the latest investigations into this subject: but I hope that the present paper may be the means of drawing more information from others. However, the main facts are clear enough. There is no great disproportion between the snow-caps of Mars; on the whole perhaps they are not far from equal. But there is a marked difference between their fluctuations: the Northern cap in fact changes slowly and little, the Southern fluctuates rapidly and much. The following facts will give an idea of their range and variation. In the year 1830 a favourable opportunity occurred for viewing the Southern cap; it was during the summer-time of that Pole, and the following measurements were taken, the times of year corresponding to our summer months being given (Breen's Planetary Worlds, p. 177) :—

June 16	Diameter of spot	12° 46′	July 7	Diameter of spot	6° 20′
—— 23	„ „	11° 30′	—— 9	„ „	5° 46′
—— 26	„ „	7° 10′	—— 19	„ „	8° 2′

Thus at a time of year corresponding to our July 9 the snow-cap fell to a minimum, and was only 5° 46′ broad. It will be seen, too, that it fell off rapidly, having been more than twice as broad a month before. This would lead us to expect a large extent in winter-time: and we find that at the opposition of 1837 a good part of the Southern snow-cap was seen, although the South Pole was then turned away from the earth (and of course from the sun too); in fact it was estimated that it extended to a distance of 35° from the Pole, though this seems to have been an exceptional occasion.

In the year 1837 similar measurements were taken of the mini-

he Northern snow-cap, with the following results, the times
ing again given in terms of our summer months:—

Diameter of spot	31° 24′	July 4	Diameter of spot	18° 24′
„ „	28° 0′	——12	„ „	15° 20′
„ „	22° 54′	——20	„ „	18° 0′

ve remark that the numbers concerned are much larger
re than double, in fact—what they are for the South Pole;
also remark a *slower* falling off towards the minimum.
more difficulty about the maximum. In the winter season
of the spots, owing probably to the state of the atmosphere,
fined; and, as already hinted, when Mars is in opposition,
fore most favourably situated for observation, the wintry
rned *away* from us, and therefore at no time is there any
ity of directly measuring the diameter of a snow-cap at its
. It is however certain, as mentioned above, that the
of the Northern cap is nothing extreme, and in all
y it is not far different from that of the Southern.

ly, to one who looks at the more general aspects of the
nothing can be more obviously likely than that that should
hich does happen at the two poles of Mars: namely that
which endures the extremely hot summer and the ex-
old winter should present the extreme of fluctuation in its
, and that that pole which endures the moderately hot sum-
he moderately cold winter should present a kind of modera-
ean in the fluctuation of its snow-cap. And I believe that
ment of the behaviour of these caps with the more obvious
the behaviour of snow under such circumstances was one
ings which confirmed Maedler in the idea (for which con-
is now no longer needed) that these white patches were
ow.

s, then, gives us, in the variation of its polar snows, a true
astronomical causes, it gives us a singular confirmation of
phy's theory; for, though the results may be exaggerated
planet, yet for that very reason they point out the more
in what *direction* we should look for corresponding results
n planet. They tell us, in fact, in unmistakable language,
r things equal, our Northern hemisphere would now be the
one. For though I have not spoken of *ice*-caps—since we
such good reason for speaking of ice as of snow on Mars—
ne would I suppose doubt that, as Mr. Murphy points out,
of glaciation must lie within the summer range of snow,
therefore the glaciated hemisphere must be that in which
ner range is largest, and the fluctuations (probably) least.
er, other things are not equal; and the able way in which
phy points out that the fact that "the climate of the
hemisphere is on the whole maritime, and that of the
continental," counteracts the effects otherwise natural to the
ispheres—that the geographical causes in fact overpower the
ical ones—must command the assent of most readers.

is one discrepancy, however, in Mr. Murphy's second paper;
parent one, *probably due to* a misapprehension on my part.

Admitting, in agreement with Mr. Croll, the existence of Southern ice-cap on the earth at the present day, which he ascril to geographical causes, while Mr. Croll ascribes it to astronomic he still seems to concur with Mr. Croll in ascribing the great exte of the Southern oceans to the action of this ice-cap. For he say "The ice-cap, as Mr. Croll has elaborately shown, will, by displaci the earth's centre of gravity, draw a greater share of ocean water the glaciated hemisphere." Now it is obviously impossible to ascri the oceanic character of our Southern hemisphere to the ice-cap, the ice-cap is itself due to the ocean climate; so obviously inde that it is impossible to believe Mr. Murphy intended to do so: yet is difficult to read his words otherwise.

But there are difficulties every way. For if our Southern ocea are *not* mainly due to the ice-cap, it has to be considered that th *may* be due to a permanent internal displacement of the cen of gravity from the centre of figure of the earth—especially if William Thomson is correct in supposing the interior of the earth be solid. And if this is the case, then the tendency of water collect in the Southern hemisphere will be a permanent one, a will always militate a good deal against the glaciation of t Northern hemisphere.

Certainly if the choice lay between supposing the great abundar of water in the Southern hemisphere to be due to a displacement the earth's centre of gravity by a polar ice-cap, and supposing it d to a permanent internal displacement, I should prefer the lat supposition. And for this reason. The probability seems immens strong that, in the process of formation of a body like the ea (whatever that process might be), the centre of gravity would take the exact position of the centre of figure—immensely stron than that it would. If the centre of gravity, however, were not the centre of figure, it would necessarily lie in the axis of rotatio in fact, the axis of rotation would not be permanent unless it pas through the centre of gravity. Thus the centre of gravity wou necessarily come to lie towards one or other of the poles; and th would result a necessary, though indirect, connexion between t pole and the preponderance of water in its neighbourhood.[1]

II.—NOTICE OF THE DISCOVERY OF UPPER DEVONIAN FOSSILS THE SHALES OF TORBAY.[2]

By JOHN EDWARD LEE, F.G.S., etc.

(PLATE V.)

IN the present state of our knowledge of the Devonian formati it seems highly desirable, if possible, to correlate any of t beds in Devonshire with those of this wide-spread formation the Continent.

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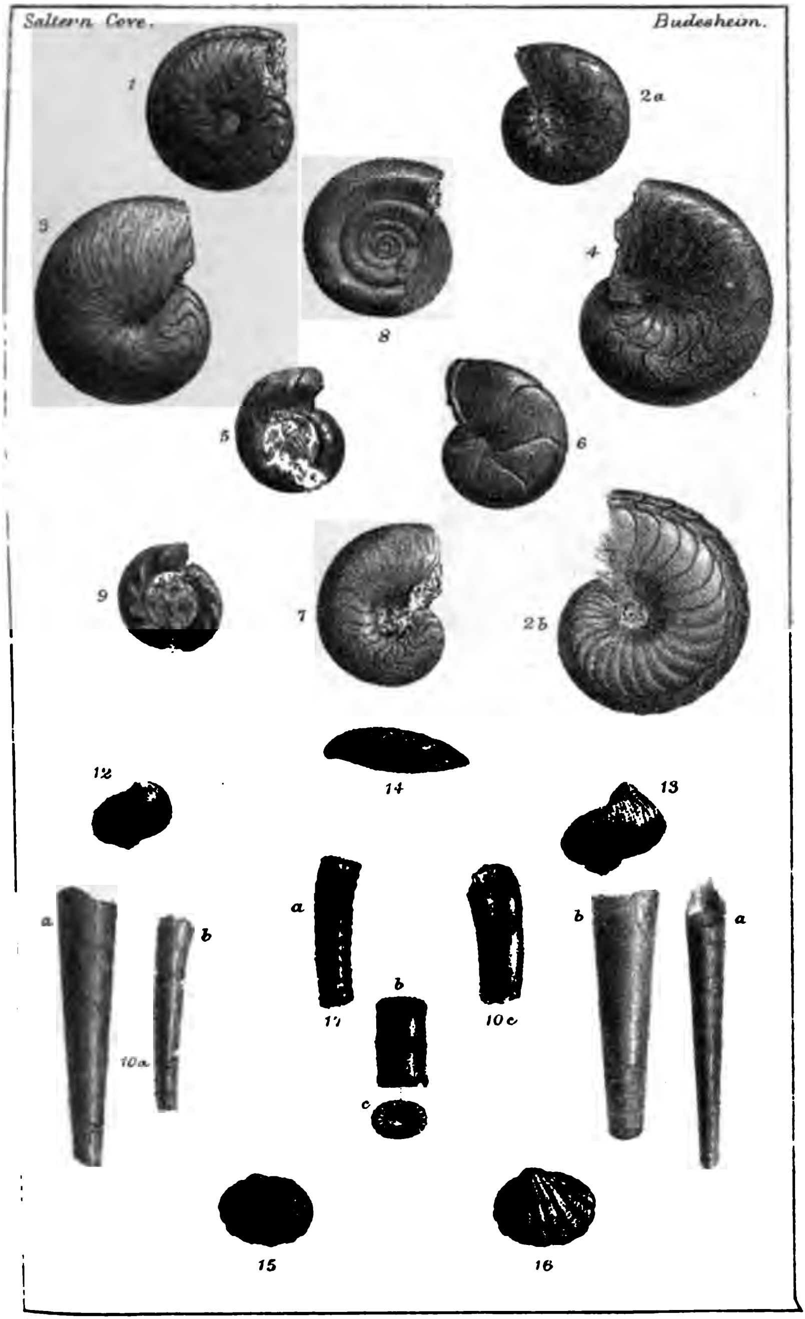
[1] An excellent article on the planet Mars appeared in the Quarterly Journal Science, vol. ii. for 1865, p. 369, from the pen of the late Prof. John Phillips, M. F.R.S., whose name is still dear to many of our geological readers.—EDIT. GEOL. M.

[2] The Editor expresses his regret that he has unwillingly detained this Not without publication for several months, the plate not having been executed.—I *GEOL. MAG.*

GEOL. MAG. 1877. NEW SERIES DECADE II. VOL. IV. PLATE V.



Edward Fielding del. et lith. W. West & Co. imp.

Upper Devonian Fossils.

Though the following notice may be very scanty, yet every well-
unded attempt to correlate the beds palæontologically is worth
mething ; and under this impression it may be desirable to place
n record the following facts.

All the old geological maps of the Torbay district colour a portion
the ground near the middle of the bay as Old Red Sandstone. Dr.
oll, in his amended map of 1868 (Quarterly Journal, Nov. 1868),
vides this "Old Red" into two parts—the "Lower South Devon"
the slates, etc., under the middle limestone, and the "Upper South
evon" or those above it; and he makes the first or the Lower South
evon (of which the Mudstone shales are a type) to touch the shore
ar or in Saltern Cove. These red shales, however, are tilted up
rather a sharp angle, and are covered unconformably by the nearly
rizontal beds of Exeter conglomerate, so that this fact alone
nders it very improbable that they are the same as the Mudstone
ales, and the following evidence from fossils seems to confirm this.

For some time Goniatites have been known to have been found
re, but they are exceedingly local;[1] in fact, so much so that,
twithstanding repeated searches, I never could discover them till
y friend, Capt. Bedford, R.N., of Paignton, and a young geologist,
friend of his, directed me where to look. The space where they
e found appears very limited, but still we soon secured a number
small Goniatites and a few other shells. From the very first the
pearance of these Goniatites reminded me strongly of those
und in such abundance in the well-known beds of shale at
idesheim in the Eifel, where a friend and I had worked in
75, and where, in the course of a few hours, we were fortunate
ough to secure a large number. It need hardly be said with what
easure we discovered at Saltern the well-known minute shell
rdium palmatum, almost, if not entirely, characteristic of the
erman shale at Büdesheim, and this discovery was followed by
hers, so that, before the day was finished, we obtained from this
ry limited locality some eight or ten species apparently identical
ith those found at Büdesheim. I have determined the following
ecies as occurring at both places.[2] (See Plate V.)

thoceras Schlotheimi, Quenst.
niatites auris, Quenst.
——— *retrorsus*, Quenst.
——— *Ausavensis*, Stein.
——— *prumiensis*, Stein.
Goniatites Gerolsteinus, Stein.
——— *primordialis*, Quenst.
——— sp. (near to *auris*).
Pleurotomaria turbinea, Stein.
Cardium palmatum.

These facts appear to me of great interest, and though I dare not
y that the occurrence of these eight or ten species in the two
alities absolutely identify the beds of Saltern Cove with those of
idesheim, yet the evidence goes a long way in this direction, and a
rther close investigation is highly desirable.

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[1] In order to indicate the place more clearly, it may be well to state that Saltern
ve consists of a larger bay to the south and a very small one to the north. The
ce where these fossils are found is to the north of the extreme point of the
adland dividing these two bays.

[2] Mr. Henry Woodward, who has examined these specimens and compared them
th those from Büdesheim, concurs in these determinations.

The German Government geologists consider the Büdesheim beds as Upper Devonian. If they are right, is it not probable that we should be correct in dropping the term "Upper *South* Devon," and simply calling these beds "Upper Devonian"?

It may be well to add that the same beds a little to the northward, at the extreme south end of Goodrington Sands, have yielded several specimens of *Pleurodictyum problematicum* and sections of large Crinoidal stems. There are also many indefinite markings in the red sandy shale bearing a great resemblance to vegetable remains.

EXPLANATION OF PLATE V.

FROM SALTERN COVE.

Fig. 1. *Goniatites auris*, Quenst.
„ 3. „ *retrorsus*, Quenst.
„ 5. „ *Aussavensis*, Stein.
„ 7. „ *primordialis*, Quenst. (nat. size.)
„ 8. „ *Gerolsteinus*, Stein.
„ 9. „ *prumiensis*, Stein.
„ 10. *a*, *b*, *c*, *Orthoceras Schlotheimi*, Quenst.
„ 12. *Pleurotomaria turbinea*, Stein.
„ 14. *Mytilus priscus*, Stein.
„ 15. *Cardium palmatum*.
„ 17. *a*, *b*, *c*, Crinoidal stems.

FROM BÜDESHEIM.

Fig. 2*a*, 2*b*. *Goniatites auris*, Quenst.
„ 4. „ *retrorsus*, Quenst.
„ 6. „ *Aussavensis*, Stein.
„ 11. *a*, *b*, *Orthoceras Schlotheimi*, Quenst.
„ 13. *Pleurotomaria turbinea*, Stein.
„ 16. *Cardium palmatum*.

(*All drawn twice* nat. size, except Fig. 7.)

III.—ON THE PERFORATE CHARACTER OF THE GENUS *WEBBINA*, WITH A NOTICE OF TWO NEW SPECIES, *W. LÆVIS* AND *W. TUBERCULATA*, FROM THE CAMBRIDGE GREENSAND.

By W. J. SOLLAS, B.A., F.G.S.

(PLATE VI.)

THE well-known genus *Trochammina* was instituted in 1859[1] by Messrs. Parker and Jones as a sub-genus for the reception of an arenaceous foraminifer, the *Rotalia* (*Nautilus*) *inflata* of Montagu. Subsequent researches led these observers in the following year[2] to elevate it to the rank of a distinct genus, and it was at the same time made to embrace the important series of forms then known as *Webbina irregularis*, D'Orb.

In the incomplete list of the genera of Foraminifera occurring in the Cambridge Greensand, furnished by me to the Journal of the Geological Society[3] some time ago, *Trochammina* is enumerated as a somewhat abundant form, on the evidence of numerous examples of what I regarded at the time as specimens of *Webbina irregularis*, and which indeed so closely resemble this species in external form and appearance, as to have led Mr. Brady to form the same opinion in regard to them as myself.

It did not occur to me to question the arenaceous character of these forms, till, in examining a thin slice of Ventriculite, preserved, like most of the fossils of the Cambridge Greensand bed, in calcic phosphate, I observed two specimens of a foraminifer in section presenting the same outline as that of the supposed *W. irregularis*, and adherent,

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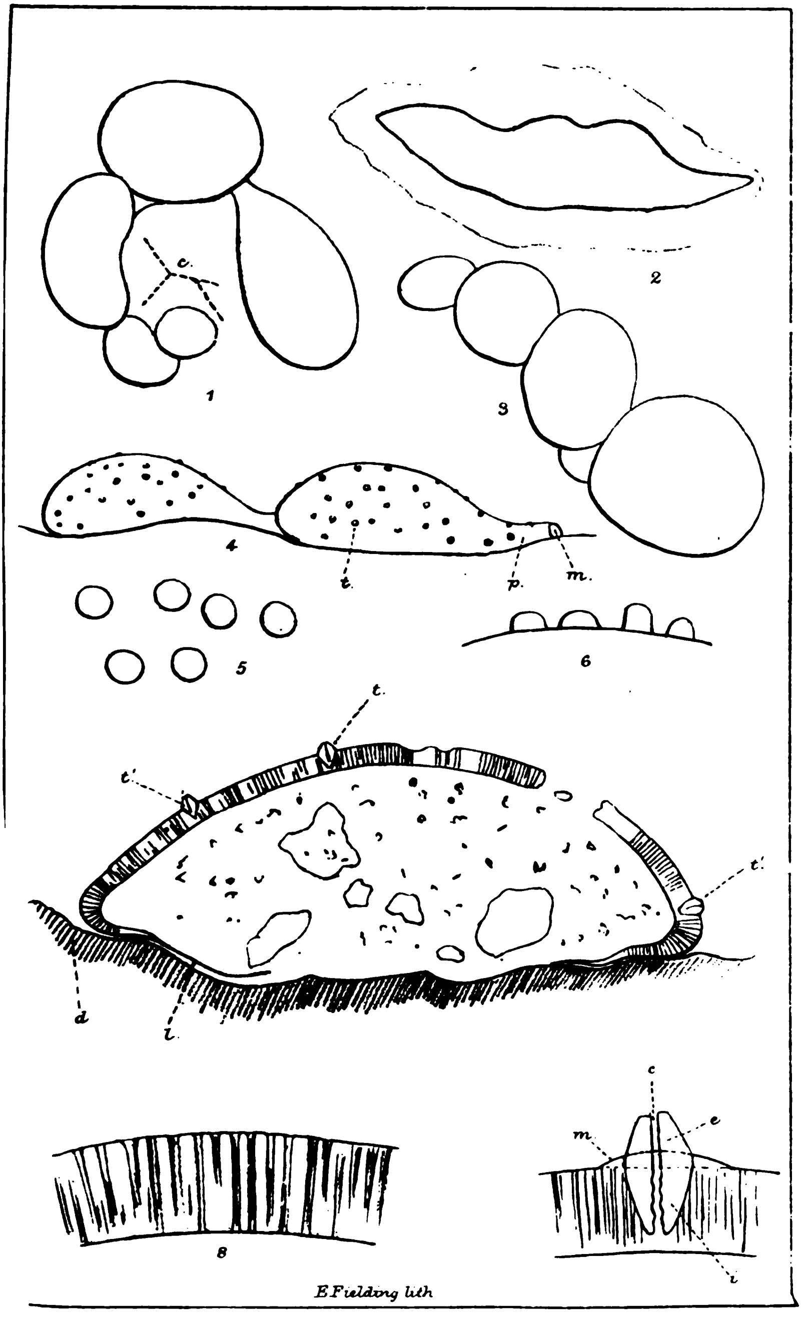
[1] Ann. and Mag. Nat. Hist., 1859, vol. iv. p. 383.

[2] Quart. Journ. Geol. Soc., 1860, vol. xvi. p. 304.

[3] Quart. Journ. Geol. Soc. 1872, vol. xxviii. p. 398.



Sollas del
W. West & Co imp.

Figs 1-3. Webbina lævis, Sollas. Figs. 4-9. W. Tuberculata, Solla

Cambridge Greensand.

to a piece of coprolite, which in this case, however, had
imbedded together with other foreign material in the second-
sit of 'coprolite' which had finally filled up the cloaca of the
Both these sections exhibited in an unmistakable manner
lation of the shell-wall which distinguishes the *Vitrea per-*
This observation led me to select some characteristic examples
pposed *Webbina irregularis* for the purpose of grinding them
to thin slices; and on examining the sections which had been
pared, the same tubulated structure was clearly revealed.
n two things were proved: first, that the section which had
t observed in the Ventriculite is that of one of the Cambridge
nd *Webbinæ,* and thus available for further observations; and
d most important, that these *Webbinæ* are truly perforate
fera.

turning now to a closer examination of the external cha-
f these forms, one finds that they comprise two kinds, one
ted with irregularly dispersed, more or less conical tubercles,
r with a perfectly smooth plain surface; the latter I pro-
call *Webbina lævis,* and the former *W. tuberculata.*
nly difference which I can distinguish between *W. lævis*
chammina irregularis exists in the structure of their shell-
itreous and perforate in the one, imperforate and arenaceous
other. Since, however, this distinction (according to the
y received classification) is a fundamental one, it requires
cognition in our nomenclature, and I venture to suggest that
ebbina-like forms which are distinctly arenaceous should
ive any other generic designation than that of *Trochammina*;
ose which are perforate should possess the exclusive right to
ny's name of *Webbina.*

Genus Webbina. (Pl. VI.)

al Characters.—Consisting of a single more or less hemi-
l, ovoidal, or pyriform chamber, terminated in many cases
rt narrow open tubular prolongation, or a succession of such
s in variable number, connected together in a moniliform
arying in direction of growth, and increasing in size from
formed onwards; always adherent to some foreign body, the
f adherence furnishing the immediate boundary wall to one
the cavity of the test, except near the circumference of the
, where the foreign substance is overgrown by an im-
bly thin structureless calcareous film or lamina, which is
n section as the fine line "*l*" in Fig. 7. White and opaque,
especially in *W. lævis* to become colourless and translucent;
smooth or tuberculate; size variable, the smallest chamber
l measuring 0·005, and the largest 0·03 of an inch in length.
e Structure.—The test is traversed throughout, in a direction
o its surface, by very fine canaliculi, less than 0·00006 of an
liameter. These are well shown in Fig. 7, and on a larger
540) in Fig. 8.
s.—1. *W. lævis,* mihi, Figs. 1, 2, 3. Surface of test smooth,

not tuberculate.—*Formation*, Cambridge Greensand.—*Locality*, Cambridgeshire.

2. *W. tuberculata*, mihi, Figs. 4 to 9.—Surface of test ornamented by a number of tubercles irregularly dispersed, generally hemispherical and depressed, resembling the rivet-heads on an iron girder. but sometimes conical and transversely truncated, average diameter 0·00115″, height 0·0008″. In some specimens the tubercles appear to be larger and more numerous than in others. A section of this species, including some instructive longitudinal sections of its tubercles, is represented in Fig. 7.

From an examination of these it will be seen that each of the bosses of the exterior is but the superficial portion of a structure which enters deeply into the test. This structure has the form of a double cone, such as would be produced by two cones fusing together by a common base, the outer and shorter one rising into a tubercle on the exterior, the longer and inner one reaching inwards, nearly, but not quite to the interior face of the test. The longitudinal axis of this skittle-shaped column or double cone is occupied by a canal about 0·0009 of an inch in diameter, simple and cylindrical in the exterior cone, but in the interior one constricted and dilated alternately either in an annular or spiral fashion, as shown by the waved outline of its margins in section.

Exteriorly the surface of the test is slightly raised to form a mound about the projecting cone, and internally the substance of the test immediately imbedding the penetrating cone is traversed by tubuli as elsewhere, which, however, stop short of the cone itself.

Formation, Cambridge Greensand. *Locality*, Cambridgeshire.

Remarks.—As the contents of the Cambridge Greensand bed have been subjected to very considerable attrition, it is just barely possible that *W. lævis* is simply *W. tuberculata*, with its outer tubercles worn off. The smooth, beautifully finished appearance of the former species does not lend any support to this conjecture however, nor do careful sections made across its shell exhibit the interior ends of the tubercular columns, which of course would remain after the exterior parts had been worn away. The conclusiveness of this latter critical test is, however, somewhat diminished by the difficulty of obtaining complete and perfect slices of such minute objects as these forms. I have not been able myself to obtain a section of more than an arc of the wall of *W. lævis*, and the completeness of the section of *W. tuberculata* shown in Fig. 7 is entirely due to the accident of its having been preserved imbedded in hard coprolite, which afforded it a firm support on all sides in the process of grinding down.

Alliances.—The minuteness of the tubulation would appear to ally these forms to the Rotaline series of Foraminifera, and the irregular method of their growth to *Planorbulina*, to the coarse perforations and projecting points of which genus the perforated columns of *Webbina tuberculata* present indeed a certain sort of resemblance; in external form there is an absolute identity of character between *W. lævis* and *Trochammina irregularis*.

Summary.—That the tubulated *Webbina*, simulating the truly arenaceous *Trochammina*, should be found in tolerable abundance in the

Cambridge Greensand, is a singular fact, when we consider that the *Bulimina* and *Textularia* of this deposit are usually very coarse arenaceous examples of these genera. The preceding observations leave no doubt however as to the existence of a Foraminifer so similar externally to *Trochammina irregularis*, as to be superficially undistinguishable from it, and which yet possesses a purely non-arenaceous and unmistakably tubulated test; and thus is added another example to the already existing list of species which may be like one another in all else, and yet differ in the arenaceous or non-arenaceous character of their walls.

Some day, perhaps, the barrier between the arenaceous and non-arenaceous Foraminifera may be broken down as an artificial separation of closely-allied forms, but on this point I may not say more now, lest I should seem to be making premature use of the information about to be published by Mr. Carter,[1] and which he has most kindly furnished me with beforehand.

EXPLANATION OF PLATE VI.

FIGS. 1 to 3. *Webbina lævis*, mihi.

1.—Outline of a specimen grown around the corner of a small angular fragment of coprolite. *c*, the solid angle of the coprolite (× 40).
2.—Outline of a specimen consisting of three chambers, which are defined from one another by slight constrictions merely (× 40).
3.—Outline of a specimen grown over the curved edge of a minute piece of coprolite (× 40).

FIGS. 4 to 7 and 9. *W. tuberculata*, mihi.

4.—Profile outline of a specimen showing the tubercles, *t*, and the anterior tubular prolongation, *p*, ending in the open mouth, *m* (× 40).
5.—Tubercles represented in plan (× 140).
6.—Tubercles shown in elevation from a lateral view (× 140).
7.—Section across a specimen adherent to a fragment of coprolite, imbedded in a subsequent deposit of coprolite within the cloaca of a Ventriculite (*V. mammillaris*). *t* and *t'*, tubercles; *l*, thin calcareous lamina, covering over a part of the surface of adherence, *d* (× 104).
8.—Tubulated wall of the test of *Webbina* (× 540).
9.—Single tubercular column of *W. tuberculata* shown in longitudinal section, with the adjacent tubulated walls of the test. *c*, axial canal with simple outline exteriorly and undulating in the inner cone; *e*, outer projecting cone; *i*, inner part of the column; *m*, mound produced by accumulation of the substance of the test about the projecting cone (× 540).

IV.—GEOLOGICAL AND HISTORICAL NOTES ON THE OCCURRENCE OF A FAUNA, CHIEFLY OF PERMIAN AFFINITIES, ASSOCIATED WITH A CARBONIFEROUS FLORA IN GAS-COAL IN THE UPPERMOST PORTION OF THE BOHEMIAN COAL-STRATA.[2]

By OTTOKAR FEISTMANTEL, M.D.,
Of the Geological Survey of India.

AS Dr. Anton Fritsch of Prague has brought the relics of Permian animals (Sauria and Fishes) from the Gas-coal of Nürschan[3] and from the "Schwarte,"[4] near Rakonitz,[5] before the Meeting of the British Association at Glasgow in September last, it will certainly not be without interest, to give some geological and historical notes on this most important occurrence, and I may, I trust, be allowed to do so in the GEOLOGICAL MAGAZINE.

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[1] *Vide* Ann. and Mag. Nat. Hist. for March.

[2] For a notice of the Animal-remains from the Gas-coal of Nyřan near Pilsen and Kounová near Rakonitz see GEOL. MAG. 1876, Vol. III. Decade II. pp. 33-34.

[3] In the Pilsen Coal-basin, S.W. Bohemia.

[4] The local name for a kind of Gas-coal.

[5] In the Kladno-Rakonitz Coal-basin, N.W. of Prague, Bohemia.

The question whether these beds, with a Fauna of Permian aspect, but occurring with a Carboniferous Flora, are to be taken as of Carboniferous age, or, guided by the animal relics, as Permian, or whether they should be considered as intermediate between the two, occupied the greater part of my time whilst engaged upon the palæontological examination of the Bohemian Coal-fields.

I have reported several times on this subject, and I constantly maintained almost the same opinion, considering these Gas-coals first as Lowest Permian, later as Passage-beds between the Carboniferous and Permian formations; but as all my reports are published in German, my repeating them in this place is certainly justified.

As the animal-remains in the Gas-coal occurred only in the above-mentioned Coal-basins,[1] I will especially speak of them.

My chief object has always been to show that in Bohemia (and certainly also in other localities) there is no strict boundary between the Carboniferous and Permian; on the contrary, that these formations are in very close connexion, as is shown in the association of a Flora of Carboniferous character with animals mostly of Permian character in the above-mentioned districts, namely, in the Gas-coals of the Pilsen- and Kladno-Rakonitz basins, which formerly, at least to a great extent, were considered as truly Carboniferous, but now must be modified, although there are still authors who assert that the Flora alone must decide the age of these strata.

A.—GEOLOGICAL AND PALÆONTOLOGICAL NOTES.

I.—*General Consideration of the above-mentioned Coal-basins.*

These the richest Coal-deposits in Bohemia can, properly speaking, be considered as only one continuous area, as they are in no place distinctly interrupted; they begin in the south-west,[2] in the neighbourhood of Dobrzan and Mantau, and extend in a N.E. direction by the city of Pilsen as far as Plass, where generally the end of the Pilsen basin is taken; but quite in the immediate neighbourhood, on the so-called "Mlatzer tanb," the other basin begins with a narrow band, which extends across Shelles, Technitz, Horzowitz, and so on across Rakonitz, Kladno, until it reaches about twenty English miles north of Prague as far as the river Elbe, where it apparently ends.

Both these basins have further in common: *a.* that there is a Coal-bearing portion, with Coal-seams of different quality and thickness in successive order, and, *b.* there is a portion of Red Sandstones without Coal-seams, or at least without productive Coal-seams, also in successive order.

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[1] Some of the same genera and species also occur again higher in the true Permian, in N.E. Bohemia, Silesia, Saxony, the Saarbrück basin, etc.

[2] See Maps of the Vienna Geological Institution.

Furthermore, the Coal-bearing group of both the basins contains two portions, a lower and a higher one.

The lower portion is truly Carboniferous, with a Carboniferous Flora and Fauna (as far as known), and contains true Coal only.

The upper portion contains in both districts, besides a thinner Coal-seam, still another stratum of Coal, in the form of a very bituminous Coal of schistose structure, which may be generally denoted as "Gas-coal" or "Gas-shale." In both basins, this Gas-coal contains animal-remains different from those in the lower portion; they are, on the contrary, such as we find generally in the Permian strata. The Flora, however, which occurs partly in this Gas-coal, but to a greater extent in the shale above, is almost throughout Carboniferous.

This stratum is therefore in both basins that of most importance, as indicating the passage from the lower and truly Carboniferous beds, to the undoubted Permian formation.

II.—*Consideration of each of the districts specially.*

Here only the objective facts are given as observed by myself and others, and as they really are seen; from these it will be apparent of what age these beds should be considered.

1. *The Coal-basin of Pilsen.*

a. THE NÜRSCHAN GAS-COAL.

This is the great Coal-basin in S.W. Bohemia, extending generally from S.W. to N.E., beginning, as I mentioned, at Dobrzan and Mantau, and spreading as far as Plass to the N.E., including especially the localities Lihn, Blattnitz, Wilkischen, Steinoujezd, Nürschan, Pilsen, Tremoschna, Dobraken, etc.[1]

Here the Coal-seams overlie each other, as is seen especially in the interior of the basin, where first an upper Coal-seam must be traversed to reach the lower one; this is especially seen in the shafts at the villages Nürschan and Steinoujezd, and further towards the north at Tremoschna.

In the shafts W. of Nürschan (as Steinoujezd, Lazarus, Humboldt), the upper seam is reached at a depth of 60 to 115 mètres from the surface; the seam itself is about 1 m. 6 dec. m. thick; immediately below it is the Nürschan Gas-coal, about 40 to 48 centimètres thick; then follows the Lower Coal-seam about 20 to 30 mètres thick.

In the immediate neighbourhood of Nürschan (station of the Western-Bohemian Railway), at the mines of Dr. Pankraz, the upper seam is reached at a depth of 24 to 54 mètres, and again immediately below, without any intervening stratum, is the Nürschan Gas-coal. This seam is therefore no doubt identical in all the shafts mentioned in the neighbourhood of Nürschan.

But the same Coal-seam with the Nürschan Gas-coal we find afterwards more towards the north—about eight English miles North of Pilsen at Tremoschna, where, in the two western shafts, "Barbara" and "Procopi," of that region, the upper seam is reached at a depth of 40 mètres, and is again underlain by the Gas-coal, of about 32 to 37 c.m. thickness—no doubt this seam is the same as that of Nürschan. Beyond the places mentioned, the Nürschan Gas-coal does not occur; at least, not so developed: this is the case generally also with the upper seam.

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[1] All these localities are well seen on the Geological Maps issued by the k. k. Geologischen Reichsanstalt.

I have discussed these relations in various papers, either wholly or partly.[1] For the extension of this Gas-coal of Nürschan, see especially my paper in the Jahrbuch d. k. k. Geol. Reichsanst. 1872, p. 289 et seq., where a little sketch-map illustrates the relations.

The most interesting part is, that this Gas-coal, as I have shown, everywhere immediately underlies the upper Coal-seam, which is at an average distance from the lower Coal-seam of about 20 to 30 mètres.

While the lower seam, the shales, and the Clay-Ironstone nodules in them, contain remains only of a truly Carboniferous Flora, as *Calamites*, *Equisetites*, true Carboniferous Ferns, *Lycopodiaceæ*, *Sigillariæ*; the Nürschan Gas-coal contains a mixed Fauna and Flora, which are the chief points of observation.

Animal-remains in the Gas-coal.

These animal-remains consist especially of *Saurians*, Fishes, and Crustaceous animals.

Dr. Anton Fritsch has already given some preliminary notes[2] on these interesting animals, and I myself repeated them and gave some figures, especially of *Diplodus*, in my short paper in the Zeitschrift d. D. Geol. Gesellsch. 1870, pl. xviii.

In the meantime Dr. Fritsch has submitted this subject to a thorough examination, and communicated his results in another short paper,[3] and lately before the meeting of the British Association at Glasgow.[4]

His examinations yielded, besides several new forms, also the well-known *Xenacanthus*, of which one is certainly *X. Decheni*, Beyr., one of the best Permian species; *Acanthodes*, one of which is very close to *A. gracilis*, Röm.; *Palæoniscus*, *Uronectes* (*Gampsonyx*), a *Julus*, which is very close to living forms, etc.

From the fact that the Nürschan Gas-coal contains these animal-remains, of which there is no trace in the lower seam, this upper Coal-seam is quite well marked and separated from that portion, though the Flora which occurs in the Gas-coal and in the shale above is almost throughout of real Carboniferous character, and many species are identical with those from the lower Coal-seam; but some few species of the Nürschan Gas-coal seem to bear Permian affinities.

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[1] Ueber Pflanzenreste aus dem Nürschaner Gasschiefer, etc., Sitzgb. d. k. bohm. Gesell. d. Wissensch. 1870.—Beitrag zur Kenntniss des Nürschaner Gasschiefers, etc., Jahrb. d. k. k. Geol. Reichsanst. Wien, 1872.—Verhältniss der Perm. zur Steinkohlenform. in Bohmen, etc., *Ibid.* 1873.—Ueber den Nürschaner Gasschiefer, etc., Zeitschr. d. D. Geol. Gesellsch. Berlin, 1873. With Plate.—Studien in bohm. Kohlengebirge, Abh. d. R. bohm. Gesellsch. d. Wissensch. 1874.—Versteinerungen der bohm. Kohlenablagerungen, 1874-6.

[2] See Geol. Mag. 1876, Dec. II. Vol. III. p. 34. Sitzungsb. d. k. bohm. Gesellsch. et Wissensch. Prag, 1870, etc.

[3] *Ibidem*, 1875.

[4] See *Nature*, September, 1876, p. 457. See also list of papers read before Brit. Assoc. Glasgow, in Geol. Mag. for 1876, p. 471.

I enumerated all the plants in my papers above mentioned, and it will be sufficient to mention the genera only, and some of the species.

Plants in the Gas-coal.[1]

Calemites (3 sp. Carbonif.), *Huttonia*, *Asterophyllites* (Carbonif.), *Sphenophyllum* (Carbonif).

Sphenopteris[2] (about 9 Carbonif. sp.), *Hymenophyllites*, *Schizopteris*, *Cyatheites* (4 sp. Carbonif.), *Alethopteris* (3 sp., important, *Alethopt. erosa*. Gutb., and *longifolia*, Göpp.); *Oligocarpia* (?), *Neuropteris*, *Odontopteris* (I think *obtusiloba*, Naum., or *obtusa*, Brong.); *Dictyopteris Brongniarti*, Gutb.; *Cyclopteris*.

Lepidodendron dichotomum, Stbg.; *Sagenaria elegans*, Stbg.; *Knorria*, *Lepidophyllum majus*, Brong.; *Lepidostrobus variabilis*, L.H.; *Cardiocarpon*, etc.

Sigillaria distans, Stbg.; *Sigillarinestrobus*, *Stigmaria*.

Walchia—I think certainly some branchlets belong here (of the common Permian form).

There are, altogether, about 50 species of plants of Carboniferous character, besides the animals, which Dr. Fritsch, from the very first,[3] recognized as Permian genera, and which he lately announced before the Glasgow meeting, as representing the passage between the Carboniferous and Permian formations.

b. PLANTS IN THE SHALE ABOVE THE UPPER SEAM.[4]

As in the Gas-coal, and also in the Shale above the Upper Coal-seam (therefore also above the Gas-coal), the Flora is still of Carboniferous character. I had occasion to determine about 75 species, mostly well-preserved and interesting plants. All orders, as *Equisetaceæ*, *Filices*, *Lycopodiaceæ*, and *Sigillariæ*, are frequently represented; *Sphenophyllum Schlotheimi*, Brong., very frequent, *Sphenopteris* abounds, amongst which truly Carboniferous forms, as *Sphenopt. Höninghausi*, *Sph. obtusiloba*, Brong.; *Sph. asplenites*, Gutb., prevailing; *Neuropteris* numerous; *Adiantites giganteus*, Göpp.; *Dictyopteris*, Gutb.; *Cyatheites*, *Alethopteris*, and especially various forms of fern trunks of the genus *Megaphytum*, which I described in a special paper.[5]

Lycopodites, *Lepidodendron*, *Sagenaria*, *Bergeria*, etc., all very frequent.

Sigillaria very abundant, with about ten species, and *Stigmaria* throughout.

With these plants from the Shale above the seam, the Nürschan Gas-coal has more than the half of its species (about 32) in common, and in both strata the Flora is to be considered as a continuation of that in the Lower Coal-seam.

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[1] See Feistmantel, Sitzungsb. d. k. bohm. Gesellsch. d. Wissensch. 1870.—Jahrbuch d. k. k. geol. Reichsanstalt, 1872, 1873.—Zeitsch. d. D. geol. Gesellsch. 1873.

[2] Most frequent *Sphenopt. Gravenhorsti*, Brong.

[3] Sitzungsber. d. k. bohm. Gesellsch. d. Wiss. 1870.

[4] See the same papers as before.

[5] Ueber Baumfarrenreste der bohm. Kohlenformation, etc., Abhandl. der k. bohm. Gesellsch. d. Wissensch. 1872, ii. *Tafeln*.

c. THE LOWER COAL-SEAM.

From this district I determined about 96 species of plants, and also a Crustacean referred to the *Eurypterida* was described as *Lepidoderma Imhofi*, Reuss.[1] A full account of these relations I have given lately in two larger papers.[2]

It is very interesting to note the occurrence of numerous Ironstone nodules in some localities in the district of this lower seam, which are in the shales above it, and contain, like the shales themselves, many well-preserved fossil plants.

The fossil plants of these spherosiderites and of other places in the Bohemian Coal-fields I have especially described.[3]

The Lower Coal-seam is generally thicker, and where it is in connexion with the upper seam, much deeper below the surface; in other localities it is reached at once when sinking a shaft, without traversing the upper seam.

d. ANIMAL FOSSILS FROM ABOVE THE UPPER COAL-SEAM.

It remains to mention another occurrence of animal-remains above the Upper Coal-seam. More in the northern part of it, about six English miles N.N.W. of the city of Pilsen, between the villages Zilow and Ledec, a Coal-seam was reached at a depth of six mètres which was only 63 c.m. thick, and contained in the lower part only some thin streaks of a variety of Coal which resembled mostly the Nürschan Gas-coal, so that I had no doubt this seam is the most northern representative of the Nürschan Upper Seam.

A little to the south of the village Zilow, I succeeded in finding (already 1871) some spherosiderites, which evidently came from above the Upper Coal-seam; they were more oblong and flat and reminded me of similar forms in the Leebach strata of the Saarbrück Coal-field, which was still more probable judging by their contents; they contained spines of *Xenacanthus* (apparently *Decheni*), *Ichthyocopros* (as they are found in the Permian strata o Northern Bohemia), ribbed fish-scales, and other bones, which mos probably belong to the Permian *Archegosaurus*.

In 1875, Dr. A. Fritsch again visited this region, and procured also from the spherosiderites,[4] several fishes of the genus *Palæoniscus*, amongst which was an *Amblypterus* (according to the las report) of 115 c.m. in length. This all speaks certainly for Permian affinities.

e. RED SANDSTONE FORMATION IN THE PILSEN BASIN.

Above all the seams we find Red Sandstones, especially in the northern and southern portion of the Upper Coal-seam district.

In the northern portion we find near the village Kottiken sand stones (arcoses) with a richly Kaolinic cement, and including numerous silicified coniferous stems of the genus *Araucarites* in the same condition as we find them in Northern Bohemia in the true Permian formation. Of these Red Sandstones I gave lately two sketches in my Versteinerungen der böhm. Kohlenformation, Cassel, 1876, pl. xiii.

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[1] Reuss, Denkschriften der k. Academie der Wissensch. Wien, 1856, p. 83.—Fritsch, Fauna der Steinkohlenformation in Bohmen, Archiv fur Naturh. Durchforsch. etc., ii. vol. 1873.

[2] Studien im Gebiete des Kohlengebirges in Bohmen, Abh. der k. bohm. Gesellsch d. Wissensch. 1874.—Versteinerungen der bohm. Kohlenformation, Cassel, 1874-76

[3] Sitzungsb. d. k. bohm. Gesellsch. d. Wissensch. 1873.

[4] I think it is the same locality, or very near, of which I just spoke.

These Red Sandstones are mostly developed in the southern part; we find them on the railway (from Pilsen to Furth, in Bavaria), near Weipernitz, and especially near Zwug, Rothonjezd,[1] Auherzen, etc. Also here we find numerous stems of *Araucarites*, and I have no doubt these Red Sandstones are truly Permian.[2]

f. General View of the Strata in the Pilsen Basin.

(descending order.)

1. Red Sandstones.	*a.* With *Araucarites.* *b.* Spherosiderites, with animal-remains of Permian affinities near Ledec and Zilow.
2. Upper Coal-seam District	Shales with Carboniferous Flora. Coal-seam. Nürschan Gas-coal, with Carboniferous Flora and a Fauna of generally Permian character. From this horizon Dr. A. Fritsch has made his largest collections.
3. Lower Coal-seam District	Shales and Spherosiderites with Carboniferous Flora. Coal-seam.

Every one studying this table will perceive that No. 1 is truly Permian, No. 3 is truly Carboniferous, and No. 2 must be taken as a passage-bed, as I have represented it in my later papers,[3] while in the first papers I took it as lowest Permian, judging from the animal-remains only.

Dr. Anton Fritsch, before the Glasgow meeting, pronounced the Nürschan Gas-coal also as a "passage-bed," a view which I had advocated already three years ago (1873). The historical development of the different opinions I give further on.

2. *The Coal-field of Kladno-Rakonitz.*

a. The Rakonitz Gas-coal, locally called "Schwarte."

This Coal-field is in the north-western portion of the area mentioned above. It extends generally E.N.E., and is the richest of the Bohemian Coal-fields. There is the same classification here as in the Pilsen Coal-basin.

The Lower Coal-seam District.

This lies immediately on Silurian rocks, and has a northern dip; the southern boundary runs from the locality Kralup (twenty English miles north of Prague) westwards across the localities Minitz, Wotwowitz, Zakolan, Brandeisl, Kladno, Lahna, Ruda, Rakonitz, Lubna, Petrowitz, and so on.

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[1] This village Rothonjezd (Roth = red) has certainly obtained its name from the red colour of the soil, which is caused by the decomposed Red Sandstones.

[2] Professor Krejci of Prague is also of the same opinion.

[3] Jahrb. d. k. k. geolog. Reichsanst. 1873; Abh. d. k. bohm. Gesellsch. d. Wissenschaften, 1874; Verst. d. bohm. Kohlenablagerungen, Cassel, 1874.

Mining is carried on there to a great extent, and there are several localities where fossils can be got. The fossils throughout are plants of Carboniferous character; and some remains of a Scorpion were procured, which were ranged by Dr. Fritsch with *Cyclophthalmus senior*, Corda.[1]

Of the plant remains, I described those from Kralup in a special paper,[2] and the others I enumerated in my general paper on the Coal-basin.[3]

All orders of Carboniferous plants are represented, and some Clay-bands in the Coal-seam are especially rich in plants.

For the comparison of this seam with others in Bohemia, the abundant occurrence of the genus *Nöggerathia* is very useful;[4] two species are found: *Nöggerathia foliosa*, Stbg., and *Nöggerathia intermedia*, K. Feistm. This species, however, Mr. Stur, of Vienna considers as belonging to the genus *Rhacopteris*, Schimp. Certainly these forms have nothing in common, and this *Nögg. intermedia*, K. Feistm., at Rakonitz, is a true *Nöggerathia*. Besides the foliage, there occurred also a fruit of *Nöggerathia*, which I called *Nöggerathiaestrobus bohemicus*, O. Feistm.

The Upper Coal-seam District.

This overlies conformably the Lower Coal-seam District, extends in a northern direction, and is especially developed in the neighbourhood of Rakonitz, near the Zbanberg at the villages Mutiowitz, Kounowa, Hredl, etc., and in the neighbourhood of Sehlan, at Stern, Libowitz, Lotausch, etc.

The Coal-seam in this district is only about 1½ mètres thick, but is immediately overlain by the Gas-coal, about 8 to 11 c.m. thick, locally called Schwarte; above this we again find shales.

The Gas-coal here is of the same importance as the Nürschan Gas-coal in the Pilsen Basin; it contains the animal-remains. These were very distinctly mentioned already by Messrs. Reuss[5] and Lipold[6] in their papers on the geological relations of these Coal-basins; they are, as far as at present known: *Ctenoptychius brevis*, Rss.; *Desmodus*, sp.; *Palæoniscus Vratislaviensis*, Ag.; *Acanthodes gracilis*, Röm.; *Xenacanthus Decheni*, Beyr.; *Diplodus; Pygopterus*, sp., etc.

From this both Reuss and Lipold drew the conclusion that this Gas-coal should be considered as Permian, and also Dionys Stur regards this Gas-coal (his Kounowa Series), as being of Permian age, while the Nürschan Gas-coal, containing many more forms of that kind, he puts down as the lowest portion of the Carboniferous.[7]

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[1] Archiv für naturh. Durchforschung von Böhmen, 1873, II. Bd. 2 Abth.

[2] Steinkohlenflora von Kralup, 1874, Abhandl. d. k. bohm. gesellsch. d. Wissensch. 4 Tafeln.

[3] Steinkohlen und Permablagerungen N. W. von Prag, 1874, Abh. d. k. bohm. Gesellsch. d. Wissensch. II. Tafeln.

[4] This I first pointed out in my papers; all other opinions about it are subsequent.

[5] Sitzungsb. d. k. Acad. d. Wissensch. Wien, 1858.

[6] Jahrb. d. k. k. Geolog. Reichsanstalt, 1861-62.

[7] It is certainly not uninteresting that only lately a *Ceratodus* has been procured [illegible]m these beds.

Here in the Kladno-Rakonitz Coal-basin the Gas-coal lies therefore ove the Coal-seam. The shale above the Gas-coal, however, con- ns again a Flora which is very distinctly Carboniferous.

I enumerated it already on various occasions.[1] I will especially te — *Calamites Suckowi*, Brong.; *Asterophyllites, Sphenophyllum, atheites, Alethopteris, Caulopteris peltigera*, Brong.;[2] *Lycopodites aginoides*, Stbg.; *Lepidodendron dichotomum*, Stbg.; *Sigillaria ernans*, L. & H.; *S. Cortei, Stigmaria ficoides*, etc. All these ur therefore above the Permian Fauna, and no Permian plants ongst them.

b. The Red Sandstone Formation.

Above this Upper Coal-seam, with the Gas-coal on top, we find e real Permian Series partly exposed near Rakonitz, but especially re to the north, near Klobuk and Perutz, where they dip under etaceous beds, and extend to the valley of the Eger river, between stelberg and Budin, as they are seen in that region on the right re of that river. In this series we have again the Permian *aucarites* stems in abundance, as in the Pilsen Basin and in the ly Permian strata in N.E. Bohemia, on the S.W. side of the esengebirge.

From near Klobuk we know *Calamites gigas*, Brong., and *Walchia iformis*, Stbg., etc. The sequence of the beds in this Coal-field therefore, generally the following:

Red Sandstones	—With *Araucarites*, *Calamites* and *Walchia*.
Upper Coal-seam District.	Shales with Carboniferous Flora. Gas-coal (Schwarte), with Permian Fauna only. The Coal-seam.
Lower Coal-seam District.	Shales with Carboniferous Flora and *Scorpio*. Coal-seam. Clay-band with Carboniferous Flora. Coal-seam.

If we now compare both these basins (Pilsen and Kladno-Rakonitz) e shall observe:

1. The group of Red Sandstones in the Kladno-Rakonitz basin is ual to the same group in the Pilsen basin, with the beds near dec and Zilow.

2. The Rakonitz-Schlan Gas-coal is rather higher in the series an the Gas-coal at Nürschan, though both contain some genera of imals in common; the Flora being, however, much more abundant ar Nürschan than near Rakonitz, seems to indicate a slow ex- ction of it towards this latter place; but this Rakonitz Gas-coal is, even by Dionys Stur, acknowledged as Permian in his mis- ding paper on that subject in Verh. d. k. k. geol. Reichsanstalt, ien, 1874, p. 194.

3. The lower seam in the Pilsen basin is of the same horizon, as the Kladno-Rakonitz basin.

This we may perhaps explain in the following way:

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[1] Abhandl. d. K. böhm. Gesellsch. d. Wissenschaften, 1873-4; Jahrb. d. k. k. eol. Reichsanst. 1874.

[2] Figured in Verstein. d. böhm. Kohlenablagerungen (Feistmantel), pl. xxiv.

The lower Coal-seam districts in both basins are characterized by a truly Carboniferous Flora only.

While this Flora still grew in abundance in the Pilsen basin, the first Permian animals appeared there at a time when the upper Coal-seam of Nürschan began to be deposited.

From this point the animals continued in the district of Kladno-Rakonitz upper Coal-seam, until the end of its deposition, while the Carboniferous Flora still existed, but was already dying out.

After this time the Carboniferous Flora rapidly died out, and was replaced by Permian forms, which, with the associated Permian animals, lived together as we find them in the northern part of Kladno-Rakonitz Coal-field, and especially in the north-east of the Bohemia, but which already began so in the Pilsen basin.

We have therefore an eastward and northward development of Permian animals and plants.

A general view may illustrate the relations :—

Upper Coal-seam District in both Coal-fields.	*a* Red Sandstones with *Araucarites*, Permian Flora, etc.
	b Spherosiderites near Ledec and Zilow, Pilsen basin; with Permian animal-remains only.
	c Carboniferous Flora (rarer), near Rakonitz.
	d Gas-coal of Rakonitz (Schwarte); Permian animals.
	e Coal-seam.
	f Carboniferous Flora, very abundant.
	g Coal-seam.
	h Nürschan Gas-Coal, Permian Fauna, and rich Carboniferous Flora.
Lower Coal-Seam District in both Coal-fields.	*i* Carboniferous Flora only, very abundant.
	k Coal-seam.
	l Carboniferous Flora.
	m Coal-seam.

As an immediate result from this consideration it follows that in Bohemia (and certainly also elsewhere) there is no strict boundary between the true Carboniferous and Permian epoch, to demonstrate which was always the chief object of my four years' examination of the Bohemian Coal-fields, all of which I saw under the guidance of Mr. Krejci, Professor of Geology at the Polytechnikum in Prague.

The same result is clearly to be seen even from Herr Stur's general view (Verh. k. k. geolog. Reichsanst. 1874. p. 208), and even Prof. Weiss does not deny it,[1] although both Weiss and Stur tried for some time to place the Nürschan Gas-coal, which is the passage-bed, much lower in the series.

But Mr. Krejci explained it very decidedly in a short, but comprehensive and clearly written paper, 1874.[2]

B.—HISTORICAL NOTES.

While local geologists and palæontologists, long resident in Bohemia, were especially engaged in the examination of these Coal-fields for many years, and had explained the relations of these Gas-coals with their Permian animals in the manner I have indicated, some foreign geologists, who never had occasion to

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[1] Zeitschrift. d. D. Geol. Gesellsch 1874, p. 364.

[2] Sitzungsb. d. k. böhm. Gesellsch. d. Wissensch. 1874, Decemb.

mine them so thoroughly, and who never had such a rich collec-
n of these animals, were inclined to consider the Flora only, and
lained their relations in a directly opposite manner.

But *in medio virtus* must also be here the guiding motto, and all
cumstances must be considered.

The age of the Gas-coal in the Kladno-Rakonitz basin, which is
ecially known for many years from the locality Hredl, was already
ognized correctly by Messrs. Reuss (in 1858) and Lipold (in
62), both taking it as of Permian age, for which they had good
unds.

I myself visited this basin for three years with Prof. Krejci, and
could only confirm again these previous observations. But I found
re. I found that the Flora from above the Gas-coal is throughout
rboniferous, and not one single species is of Permian character.

I discussed these relations first in my special paper on this basin,[1]
d they are also to be found in my subsequent general papers.[2]

Here I was the first who pointed out the analogy of the lower
al-seam with the Coal-strata of Radnitz,[3] and described first, more
detail, the localities of the Gas-coal with Permian animal-remains,
d a Carboniferous Flora, in the shales above.

Herr Stur, of Vienna, expressed about this Gas-coal, in one and
e same year, two rather different opinions. In his misleading
per on the Bohemian Coal-fields,[4] on account of the animals, he
ats the Gas-coal (Schwarte) without hesitation as truly Permian
r as he prefers calling it, Dyas[5]); but he established a superfluous
me for this Gas-coal, calling it "Kounowa Series," while, if a new
me be made at all, it should be called Hredler Series, being much
nger and much better known from the locality of Hredl.

In a note, in the Verhandl. d. k. k. geol. Reichsanstalt, 1874,
rr Dionys Stur reports on plants from the district of the Gas-coal,
d says distinctly that till that time no plants from this district
re recorded, although my special paper on the Kladno-Rakonitz
sin was already published, and Herr Stur was acquainted with it.
re I enumerated the first plants from above the Gas-coal. Herr
ur was obliged to recognize that those plants were only of Carbon-
rous character. To be able to explain it, Herr Stur at once re-
ved the position of the Gas-coal to the very beginning of the
rmian, in which he might perhaps not be wrong, although at first,
lging from the Fauna only, he thought it higher. We see, how-
er, that the Permian character of this Gas-coal is so apparent that
rr Stur could not transform it, although he would certainly have
ed to do so.

Prof. Krejci, in his excellent short paper,[6] pronounced the last

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Abhandl. d. k. böhm. Gesellsch. d. Wissensch. 1873.

Geologischen Reschsanst. Wien, 1873. Abhandl. d. k. bohm. Gesellsch. d.
ssensch. 1874. Verst d. bohm. Kohlenablangerungen, Cassel, 1874–76.

Hurr Stur, of Vienna, did so later, when my paper was already published, and
hout mentioning it, although aware of its existence.

Verh. d. k. k. geol. Reichsanst. 1874, p. 189, et seqq.

This unfortunate word is certainly very inappropriate and confusing.

Sitzungsb. d. k. bohm. *Gesellsch. d. Wissensch.* 1874.

opinion, taking this Gas-coal in the Kladno-Rakonitz Coal-field to be analogous to the Kohlenrothliegendes in the Saarbrücken basin, or in other words as Lower Permian, in which my own explanations were acknowledged.

About the Nürschan Gas-coal, from which so many more animals are known, and from whence Dr. A. Fritsch has obtained the greater part of his material, the literature is a little more complicated.

First we find the Gas-coal mentioned in Prof. Geinitz's voluminous and important work, "Steinkohlen Deutschlands und anderer Länder Europas," 1865, i. vol.; but the Professor did not know any animals from there, and of the plants only two species are specially mentioned, amongst which, as the most frequent, *Sphenopteris Gravenhorsti*, Brong., which I found again in my examinations. The Professor knew the Gas-coal also only from the mines in the immediate neighbourhood of Nürschan.

More lately, however, in 1870, I visited this Coal-field and collected plants in the more western mines of Nürschan, as well from the Gas-coal as from the Shale above, in the mines of Dr. Pankraz, while Dr. Anton Fritsch had already at that time some material of animal-remains to determine.

At that time he wrote the first note[1] and spoke of these remains as Permian; at the same time I wrote my first paper on th plant-remains from this stratum in June, 1870,[2] and pointed ou already strongly as very interesting the occurrence of this Permia Fauna with an almost entirely Carboniferous Flora.

In a reference to this paper of mine in Geinitz und Leonhard' Jahrbuch, 1870, the Carboniferous age of the plants was acknowledged, the Permian character of the animals could not be denied and to explain this, an immigration or colonization of tho migratory animals (as they are called there) in the Carbonifero strata was suggested as possible. But it certainly says that in o Pilsen basin the Carboniferous Flora was still growing, while the Permian animals had already begun to live, which only proves t existence of the former in Permian times.

Later I paid three more visits to this Coal-field and wrote m other papers on this subject.[3] In all these papers I declared a palæontological maxim, that in this case the animal-remains wi certainly have to decide, and that a surviving of an already exis ing Flora is more natural, and I then declared the Nürschan Ga coal as also of lowest Permian; parallel with Herr Weiss's Kohle rothliegendes.

Prof. Geinitz, however, maintained his view of an "immigratio of "dyadic forms."

[1] Sitzungsberichte der k. bohm. Gesellsch. d. Wissensch. 1870. April.

[2] *Ibidem*, June, 1870.

[3] Beitrag zur Kenntniss und Ausdehnung des Nürschaner Gasschiefers, etc., Jah d. k. k. geol. Reichsanst. 1872.—Ueber das Verhaltniss der bohm. Kohlen- u Permformation, etc., Ibidem, 1873.—A letter to Prof. Geinitz, in Geinitz u Leonhard N. Jahrb., 1872, p. 303.—Ueber den Nürschaner Gasschiefer, Zeitschr. D. geol. Gesellsch. 1873.—Ueber Verbreitung und geol. Stellung der verkieselt *Araucaritenstamme*, etc., Sitzungsb. d. k. bohm. Gesellsch. d. Wiss. 1873, etc.

In the mean time I entered into correspondence with Prof. Weiss in Berlin, who classified in a similar manner the Saarbrücken Coal-field, and he communicated to me his opinion that our Nürschan Gas-coal will most probably be analogous to his Otweiler Series, forming the transition from the Carboniferous to the true Permian, which he stated also in an exposé in the Zeitschr. d. D. geolog. Gesellsch. 1874, pp. 367–69, referring to my paper "Verh. d. bohm. Kohlen zur Permform. l.c."; he could not deny the fact, that the Carboniferous and Permian strata appear only as members of one formation, to show which was always my chief intention; this statement of Weiss was therefore a great satisfaction to me. But I yet must recall to mind that Weiss himself gave as characteristic for his Otweiler Series a Carboniferous Flora, without a Permian Fauna, which, however, is so numerous in our Gas-coals at Nürschan (and Rakonitz), that they certainly never can be mistaken for Carboniferous.

In consequence of this I adopted, in a certain way, Herr Weiss's view (in a letter to Dr. Geinitz, in Leonh. und Gein. Jahrb. 1874), considering this Nürschan Gas-coal (therefore the whole upper seam) as passage-beds, which may be called Otweiler Series, in the Saarbrück basin, but strongly advocating the close connexion of this with the Permian formation, and citing the abundance of *Xenacanthus*, *Acanthodes*, etc.

This view I used afterwards again in my general works,[1] but only for the Nürschan Gas-coal, considering it parallel with Weiss's Otweiler Series, as passage-beds, while the Rakonitz Gas-coal I placed at the beginning of the Permian.

I gave the following table:

Permian	The true Red Sandstones, with Permian Fauna and Flora.
	Spherosiderites of Zilow and Ledec.
	Rakonitz Gas-coal.
Otweiler Series Passage-Beds	Above Carboniferous Flora.
	Nürschan Gas-coal, with Permian Fauna and Carboniferous Flora.
	Upper seam of the Coal-field at foot of the Riesengebirge, near Radowenz.
True Carboniferous	Lower Coal-seam district.

This was the state of the question, on my part,[2] when I left for India, engaged on the Geological Survey, after having examined for four years the Bohemian Coal-fields.

When all the above was written, for the most part with the approval of Mr. Krejci, Professor of Geology, and Dr. Ant. Fritsch, Professor of Zoology and Palæontology in Prague, two visitors, Herr Stur, from Vienna, and Herr Weiss in Berlin, came to see the Pilsen basin. They had, of course, a very easy task, as they had already a great amount of important papers for their guidance.

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[1] Studien im Gebiete des bohm. Kohlengebirges; Abh. d. k. böhm. Gesellsch. d. Wissenschaften, 1874. Verst. d. bohm. Kohlenabl., Cassel, 1874–76.

[2] My paper, "Studien in Kohlengebirge," etc., was later discussed in *Nature*, July 27, 1876, p. 270, where the reviewer concludes as follows: "But faults like these will not detract from the real value of the work; when the time comes for a rectification of boundaries on the Permo-Carboniferous frontier, the vast mass of carefully-observed facts which it furnishes will form no unimportant contribution to the body of evidence by which the question must be decided. The author may have been premature in his conclusions, but his industry and application have produced a work that will have a permanent value."

As I have already mentioned, Herr Stur published in 1874 a paper in the Verhandl. d. k. k. geolog. Reichsanstalt,[1] which, however, must be taken with precaution, as it contains a great many assertions, mostly without proof; therefore Herr Stur must naturally expect that, as he is not infallible, his views are open to objections.

Herr Stur took, also, as I did before, the Rakonitz Gas-coal as *Permian*, although, as I first proved (l.c.), the Flora above is *Carboniferous;* but for the Nürschan Gas-coal he has chosen another opinion, and pronounced this Nürschan Gas-coal as parallel to one of the "lowest Carboniferous horizons" in Bohemia. This was done with such a degree of certainty (but always without arguments) that my conclusions on this subject seemed struck down, but fortunately only for a short time. Herr Stur did well not to deal with the occurrence of the animal-remains, which would certainly not have fitted in with his well-made system in words.

About the same time Herr Weiss, from Berlin,[2] came to see for a short time the Pilsen basin, and at once wrote a Report on what "he had seen"; in a letter to Prof. Geinitz,[3] which is signed by him and another gentleman, apparently as witness. In this the Nürschan Gas-coal, certainly only from a superficial view, is also attributed to the lowest Carboniferous horizon in Bohemia; but the animal-remains were not considered at all, which, however, must be absolutely done, to gain a correct idea of its relations. Mr. Weiss on the contrary, in his note in Zeitschr. d. D. geol. Gesellschaft, 1874, p. 368, discussing my paper on the relation of the Permian and Carboniferous in Bohemia, went so far as to say—when comparing the Nürschan Gas-coal with the Otweiler Series—that in the latter no *Xenacanthus* has been found, which, however, as Herr Weiss thinks, is of no importance (l.c. p. 368 below), and yet he was the first, who in his paper "Leitfische des Rothliegenden in den Leebacher und aequivalenten Schichten des Saarbrückisch-pfälzischen Kohlengebirges,"[4] mentions *Acanthodes, Xenacanthus, Palæoniscus*, etc., as the most characteristic genera for the Permian strata.

A mining engineer, now lecturer in the Mining Academy at Leoben, Herr Helmhacher, went still further, and endeavoured to prove,[5] from the mineralogical relations, that this Nürscham Gas-coal is something like the English Bog-head Coal, and therefore also of Lower Carboniferous age: "*quod erat demonstrandum*," thought the gentleman. But the imagined victory of these outside observers was only of short duration.

First I have to notice the repeatedly pronounced opinion of the well-known Prof. F. Römer of the University of Breslau, that he considers the Nürschan Gas-coal as corresponding with a similar deposit at Klein-Neundorf in Silesia, which is indeed so.

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[1] Momentaner Standmeiner Untersuchungen über die unsseralpine Steinkohlenformation, April, 1874.

[2] He writes notices and reviews under the signature, W. in Berlin.

[3] N. Jahrb. 1874, pp. 963–964.

[4] Zeitschrift d. D. geol. Gesellsch. 1874.

[5] See Verh. d. k. k. geol. Reichstlt. 1876, p. 213; N. Jahrb. etc., 1876, p, 104.

Very soon after Herr Stur's paper, with an amount of facts without arguments, a simply but clearly written article by the Bohemian local geologist, Prof. Krejci, appeared,[1] wherein the Professor, after many long years of experience and practice in Bohemian geology, has explained the matter in a most natural way.

While acknowledging the abilities of all the authors, who have written on the subject, he yet for good reasons cannot concur either in Herr Stur's or Herr Weiss's opinions, and he adopts that view which I have illustrated so repeatedly.

He says in the conclusion of his paper (I give the translation): "The Bohemian Coal-formation, and especially the Pilsen basin, forms therefore a connected series of strata, of which the Lower portion (Radnitz, Kladno, Pilsen, etc.) is parallel with the Saarbrücken Series, the higher portion (Rakonitz Gas-coal) with the Cuseler and Leebach Series, while the Nürschan Gas-coal, however, has to be put at the base of the Kohlenrothliegendes of the Saarbrück basin, or it is analogous with the Otweiler Series,[2] which classification may decide the present state of the question about the age of the Nürschan Gas-coal."

This result is the same which I had arrived at in my later papers, and this paper of Prof. Krejci was the first energetical contradiction of the opinions of those gentlemen I mentioned above.

But a still more important expression of opinion in that way is Dr. A. Fritsch's presentation of his results of the examinations of the Fauna from the Gas-coals before the last Glasgow meeting. Dr. A. Fritsch declared the animals to be mostly of Permian character, and these beds as passage-beds between Carboniferous and Permian in Bohemia, just as I did, and as Prof. Krejci stated again, and this after duly considering both kinds of organisms.

Thus Herr Stur and Herr Weiss had a very short time the satisfaction of having contradicted my views, as they have been so evidently re-established by our best local geologists and palæontologists, and we can always suppose that good local geologists, who are also excellently acquainted with all other relations, will and can decide a question better than a visitor, who only casually examines the subject.

I felt obliged to bring this subject forward, in the GEOLOGICAL MAGAZINE, in order to give English readers an indication where to find, if required, the several papers on this question, so important in its bearings on the subject of the boundaries of the Permo-Carboniferous formation in general, and by way of caution as to Herr Stur's publications in that direction. But here again, *in medio virtus.* Where plants only occur, they may decide the horizon, if they are analogous with known and already determined floras; where animals only occur, they must decide from their part but if both animals and plants occur, they must both be used in a appropriate way; but we must always take this maxim for our guidance, that already existing organisms could much easier survive, than that organisms generally known as higher in stratification should be transferred to much lower strata; and how such cases can be explained by colonization, everybody knows best for himself, and I have indicated already above.

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[1] Sitzungsb. d. k. böhm. Gesellsch. d. Wissensch. 1874.

[2] These are the passage-beds, to which I also referred the Nürschan Gas-coal.

We must further consider that formations in general have proved not to be so strictly limited, and that very often forms from the lower pass into the higher, as for instance the Rhætic beds, as passage-beds between the Keuper and Lias; the Wealden formation, as a passage-bed between the Upper Jura and Lower Cretaceous, etc., were established; there is certainly such a passage also between the Carboniferous and Permian formation, and in Bohemia the Nürschan Gas-coal establishes this passage: it is therefore to be considered as a passage-bed between the Carboniferous and Permian formations there.

NOTICES OF MEMOIRS.

I.—On the Tertiaries of Malta.[1] By Th. Fuchs. Proceed. Imp. Acad. Vienna, Jan. 20, 1876, vol. lxx. p. 92.

[Communicated by Count Marschall, C.M.G.S., etc.]

THESE Tertiaries may be divided into two groups; the upper on answering to the Leitha-limestone of the Vienna Basin; th lower one to the deposits of Schio near Vicenza, of Monte Titan near San Marino, of Dego, Carcare, and Belforte in Italy, those o Bazas and Merignac in France, the Marine Molasse of Bavaria, th Sotzka beds of Styria, and the Pectunculus beds of Hungary. Th two groups are conformable; but, though petrographically analogous offer different palæontological characters.

The succession of beds (in descending order) is:—

A. *Leitha-Kalk Group.*

1st.—Leitha-limestones in all the varieties occurring in the Vienn Basin, and a peculiar compact variety with breccia-like texture bearing more resemblance to the Triassic "Rauhwackes" of th Alps than to any Miocene Leitha-limestone.

The plateaux formed of these limestones are notably worn out b atmospheric agencies, their superficial erosions being filled by brick-red earthy substance, like those of the Illyrian Karst. Organi remains, identical with those of the Leitha-limestones of the Vienn Basin, are locally abundant.

2nd.—*Green Sands and Heterostegina-limestones* of Gozo, immediately beneath the Leitha-limestones with an enormous quantit of *Polyzoa*, *Heterosteginæ*, *Echinidæ*, *Ostreæ*, and *Pectines*, and i every respect answering to the sands of Neudorf, south of Vienna.

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[1] Papers on the Geology and Fossils of Malta, by Duncan, Jones, and Hutton have appeared in the Geological Magazine, Vol. I. pp. 96—106, and Vol. III 52, which may be consulted in connexion with this communication.—Edit

3rd.—*Plastic Clay* ("Schlier" of the Vienna Basin). with a thickness of 180 feet, abounding with *Nautilus Aturi*, Bast. (*Naut. diluvii*, Sism.), *Pecten denudatus*, Reuss, and *Pecten*, sp. nov.

B. "*Bormidian-Aquitanian.*"

1st.—*Pecten-beds*, answering to the Schio-beds, finely arenaceous, soft, with an abundance of small *Echinidæ* and *Pectines* (*P. Haueri*, and *P. deletus*); the chief building material of Malta.

2nd. —*Lower Limestones*, chiefly developed in Gozo, visible in Malta for longer or shorter distances along the coast. Composed of detritus of Nulliporæ and Polyzoa; hard and compact. The characteristic organic remains are small *Scutellæ*, identical with those of Schio, gigantic *Orbiculinæ*[1] and *Orbitoides*, some four inches in diameter. Shells are abundant; most of them are analogous to those of Castel-Gomberto and Sangonini; but some are of the Miocene type, such as *Turritella cathedralis.*

II.—NOTE SUR LES DÉPÔTS CRÉTACÉS LACUSTRES ET D'EAU SOUMÂTRE DU MIDI DE LA FRANCE, par M. PH. MATHERON. (Bulletin de la Société Géologique de France, 3e série, vol. iv. pp. 415-428.)

THE author is of opinion that the beds of fresh and brackish water deposits that occur in Central France, and which were at one time considered to be entirely of Miocene age, represent not only almost all the Tertiary series, but even some of the uppermost beds of the Chalk.

Starting at the Chalk with *Ostrea Matheroniana*, the lowermost bed of the Sénonien, as a base-line, there follow in ascending order in the Department of Bouches-du-Rhône, zone of *Ostrea acutirostris*, the littoral beds with *Cassiope Coquandiana*, brackish-water beds, Fuveau series, Rognac series, and the large series of red claystones. All these M. Matheron classes as Cretaceous; all above being referred to the Tertiary period. The "terrain Garumnien" of M. Leymerie is correlated with the two last named of the above series, *i.e.* uppermost Cretaceous.[2]—B.B.W.

III.—RECORDS OF THE GEOLOGICAL SURVEY OF INDIA, VOL. IX. PT. 4.

CONTAINS on p. 154 a notice of the discovery of the remains of a *Plesiosaurus* in the Umia (Tithonian and Portlandian) beds at Burroria, in Kachh.

The specimen, which is the first indication yet found of the presence of this reptile in India, "comprises the whole of the symphysis and small portions of the rami of the mandible; on the right side it contains the alveoli of five teeth, and on the left side, of four." It "agrees almost exactly in form and size with *P. dolichodeirus* of the Lias." This interesting specimen, which doubtless will not long remain unique, was found by Mr. A. B. Wynne, and is described by Mr. R. Lydekker, of the Indian Geological Survey.—B.B.W.

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[1] *Orbiculina* is not noticed in GEOL. MAG. Vol. III. p. 152, as a Maltese fossil.—EDITOR.

[2] M. Hébert (Bull. Geol. Soc. de la France, 3e série, vol. iii. p. 595) had classed the Garumnian *beds as Upper Senonian*, and the Rognac beds as Damien (?).

REVIEWS.

I.—CAMBRIDGESHIRE GEOLOGY. A SKETCH FOR THE USE OF STUDENTS. By T. G. BONNEY, M.A., F.G.S., etc., Tutor and Lecturer in Natural Science, St. John's College, Cambridge. (Deighton, Bell & Co., 1875.)

THIS sketch of Cambridgeshire Geology is stated in the preface to have been published to give to beginners some information on the local geology of this district. A pamphlet on this subject was privately printed by the late Prof. Sedgwick in 1861. Since that period many papers have been written on the geology of this part of England. Mr. Bonney gives a short account of the strata of the Mesozoic period, and the nature of their variation when traced diagonally across England from the southern counties. The physical geography of the Cambridge district is thus described: "The valley of the Cam is a wide alluvial plain, bounded on the eastern side by a clearly-marked escarpment of the Lower Chalk, on the western by a more irregular hilly district, consisting partly of outliers of Lower Chalk, partly of inferior deposits capped by Boulder-clay. The right bank of the valley is formed by the edge of the great Chalk plateau, which has been corroded by the action of rain and rivers into undulating hills and valleys. From this Chalk plateau sundry streams descend towards the Cam, forming wide valleys with shelving sides, occupied in places by alluvial deposits. The fen land does not extend to Cambridge, its nearest inlets are four to five miles distant; thence it extends to the sea, as a widespread tract of perfectly flat land, scarcely above the sea-level." Next follows a description of the Jurassic strata, which, in the neighbourhood of Cambridge, consists of a vast argillaceous deposit, with a few local and partial calcareous beds, the lower part of which is Oxford Clay, and the upper part is Kimmeridge Clay; in some places these graduate one into the other, without any very clear line of demarcation. The lower beds of the Oxford Clay, containing *A. Duncani*, etc., may be seen at St. Neots; the higher beds at St. Ives, where the deposit consists of a pale bluish-grey fine clay, with occasional calcareous concretions, crystals of selenite, and lumps of pyrites often altered into limonite. *Gryphea dilatata* is very abundant, also *Am. cordatus*, *Mariæ*, *Eugenii* and *Hecticus*, and *Belemnites hastatus*. The most important of the calcareous zones is that at Elsworth, described by Prof. Seeley (Ann. and Mag. Nat. Hist. ser. iii. vol. x. p. 98). The Transition Clay has been called by Prof. Seeley Ampthill Clay. Near Upware there is a low broad ridge of Limestone, which Mr. Bonney regards as a representative of the Coralline Oolite.

The Kimmeridge Clay is best seen at Roslyn Pit, near Ely. It is of a bluish-black colour, containing Septaria. Among the fossils are *Lingula ovalis*, *Ostrea deltoidea*, *Exogyra virgula*, *Am. biplex*, *Trigonellites latus*, and several genera of fishes and reptiles. The Neocomian deposits of Potton and Upware are next described. Mr. Bonney adopts the same view with regard to the age of these deposits as that expressed in papers which have appeared in this MAGAZINE. The Gault in this district is described as a pale bluish-grey tenacious clay, in which are concretions of iron pyrites, small crystals of selenite, and light brown phosphatic nodules; its thickness at Cambridge is about 115 feet, near Hitchin 214. Its upper surface is uneven. The base of the Gault contains several fossils, as *Inoceramus concentricus, Nucula pectinata, Belemnites minimus*, etc. Resting on the eroded surface of the Gault there is a stratum barely a foot in thickness, full of green grains of glauconite and black nodules of phosphate of lime, looking like a sediment from the purer marl above; it contains erratic boulders covered with *Plicatula sigillina*, as was pointed out by Prof. Seeley in the third volume of this MAGAZINE. This bed is remarkable for the number of fossil fishes, Deinosaurs, Ornithosaurs, Chelonians, etc., which it contains; Mollusca, Crustacea, Cœlenterata, Foraminifera, are also abundant. Mr. Bonney supposes the phosphatic nodules to have been formed by concretionary action. He regards some of the fossils as having been derived from the Gault. We cannot agree with him in calling this seam Chloritic-marl; as the fossils proper to the bed are those of the Chalk-marl, and the characteristic fossils of the Chloritic-marl are almost entirely absent. The Chalk round Cambridge contains *Holaster subglobosus, Inoceramus Cuvieri*, etc. (see Seeley, GEOL. MAG. Vol. I. p. 153). The Post-Pliocene deposits of Cambridgeshire are described in the following order:—1. Boulder-clay. 2. Coarse Hill Gravel. 3. Fine Gravel of the Plains—this is well seen at the Barnwell Gravel Pit; it contains *Cyrena fluminalis, Hydrobia marginata* and *Unio littoralis*, all now extinct in England; along with these are found existing species of land and fresh-water shells, and bones of *Bos, Equus, Rhinoceras tichorhinus, Elephas, Hippopotamus*, etc.; flint implements have also been found. A deposit of gravel at March contains marine shells. 4. Older Peat. 5. Buttery Clay. 6. Newer Peat.

Next follow five appendices to the work. The first contains an account of the Upware Sections, with which the readers of this MAGAZINE are well acquainted. The second, an account of the Roslyn Pit, Ely, reprinted from this MAGAZINE. Third, a short account of the Hunstanton Red Rock, which Mr. Bonney considers probably to represent palæontologically the Cambridge Greensand. Fourth, on the Water Supply of Cambridge, which is derived from three sources: 1. Old river gravels: 2. From springs at the base of the Lower Chalk; 3. From artesian wells driven through the Gault into the Neocomian Sands from 100 ft. to 150 ft. deep. Fifth, on the Building Stones, etc., employed in Cambridge—the white bricks from the Gault; red bricks of St. John's College from London Clay of Suffolk; Magnesian Limestone, the lower part of King's College Chapel; Inferior Oolite from Aislaby, near Whitby, great room of University Library and Woodwardian Museum; Lincolnshire Limestone, King's College Chapel, New Courts of St. John's and Trinity, etc.: Bath Oolite, University Press and Observatory; Portland Oolite, Senate House, façade of University Library, Fitzwilliam

Museum, Fellows' buildings of King's College; Lower Chalk, interior of several churches; it is called Clunch.

This work, along with Mr. Whitaker's list of geological papers on Cambridgeshire, will not only be very useful to students at Cambridge reading for the University examinations, but will also be very interesting to old members of the University, and we can strongly recommend it to readers of this MAGAZINE who wish to obtain a clear and correct view of what is at present known of the Geology of Cambridgeshire, as a carefully prepared and well-written book.

J. F. W.

II.—ON THE ORGANIZATION OF THE ORNITHOSAURIA. Linnean Society's Journal—Zoology. Vol. XIII. 1876, pp. 84–107. By Professor H. G. SEELEY, F.L.S., F.Z.S., F.G.S.

THIS is an important paper upon an interesting palæontological subject, for but in few instances have the hard lines of classification been more difficult to define, or have led to greater divergence of opinion among the most eminent of European naturalists, past and present, than has that of the natural position of the Pterodactyles in regard to their affinities: whether they should be classed with the Birds on the one hand, or with the Reptiles on the other. It is true that the weight of authority, whilst admitting some important anomalies in their organization, refer them to the latter class. Prof. Owen's name of Pterosauria being generally accepted for the group. But other naturalists consider that their peculiar organization, as deduced from their osteological remains, entitle them to be elevated into a distinct group or Order, intermediate between birds and reptiles, and for which group the designation ORNITHOSAURIA was proposed by Prince Charles Buonaparte in 1838. Among the advocates of these views is the author of the memoir under consideration, and in which he maintains, aided by further observations and additional facts, the opinions enunciated some seven years ago in his useful and interesting work on the Ornithosauria in the Woodwardian Museum, Cambridge (see notice in GEOL. MAG. Vol. VII. p. 341).

From careful comparisons of the various bones of the skeleton of these extinct volants with the corresponding bones in birds and reptiles, he here describes in detail the points in which they most resemble, or depart from, the typical characteristics of the groups with which they have been compared; and maintains that the results of his later examinations confirm his previous convictions, and fully demonstrate that the organization of these old volants was decidedly more avian than reptilian.

The most important characters upon which he relies for the claims of the Pterodactylia to be classified as a distinct Order, are the pneumatic foramina and the form of the brain-cavity, believing that "brains and lungs are organs of incomparably greater value in questions of organization" than manus or pes,—organs, in which, according to Prof. Huxley, the Pterodactyles depart most widely from the ornithic type.

With regard to the pneumatic foramina, he asserts that they are essentially avian in character, and are not "adaptive modifications," to any reptilian form "consequent upon the parts of the body having had to perform identical functions—seeing that the *Cheiroptera* among mammals have great powers of flight without the skeleton being pneumatic." Upon this character he also further remarks: "The pneumatic foramina of Ornithosaurs so closely resemble those of birds in almost every bone of the skeleton, that the resemblance often amounts to complete coincidence. The holes are usually in exactly the same positions on each of the bones in both groups; and in both they have the same details of reticulate structure. It must then be sound physiology to infer that such identity of structure is due to identical causation." These well-ascertained facts, in the author's opinion, tend to prove that the respiratory and circulatory organs were near akin to those of the bird, and, as a consequence, the Ornithosaurs were hot-blooded, and therefore not reptilian. Prof. Huxley, commenting elsewhere upon the high development of these organs in the Pterodactyles, thinks it highly probable that they had hot blood, but nevertheless that they were reptiles, with special modifications for special purposes. These conclusions Prof. Seeley contends cannot be accepted.

We may here remark that Prof. Owen, in his latest memoir upon these animals, as positively maintains that their affinities are reptilian rather than avian, and that by the absence of feathers as a heat-conserving covering they were also cold-blooded. It is a remarkable fact that no trace of scales, hair, or feathers, or of integumentary covering, have ever been found associated with their osteological remains in deposits, like the Solenhofen Limestone, so peculiarly adapted for their preservation.

The other vital character that Prof. Seeley advances in support of his argument is the stucture of the brain; the evidence for which "rests upon the form of the cerebral hemisphere in *Pterodactylus longirostris* and other specimens from the lithographic slate," on a specimen from the Wealden, and on some fragments showing portions of the brain-cavity from the Cambridge Upper Greensand; these he compares with the brain-cavity in the skull of an Owl, and fully describes, with minute anatomical detail, the many points in which the structural characters are common to both, and as the result of these comparisons he observes, that "the resemblance of form and arrangement of parts between this fossil animal's brain and the brain of a bird amounts, as far as the evidence goes, to absolute identity—the cerebrum being the cerebrum of a bird, the optic lobes those of a bird, and the cerebellum that of a bird, no more perfect specimen could add to the force of the conclusion that the Ornithosaurian brain is an avian brain of typical structure." On these resemblances in vital structure chiefly rests the claim of the Ornithosauria to be classified with the birds, which if allowed, they are only separated from the carinate and other birds by such modifications of the skeleton, as distinguish Cetacea, Carnivora, and Monotremata among Mammals from each other.

The recent discovery in America of undoubted ornithic remains, which, in addition to other skeletal modifications, have teeth implanted in sockets, is, as far as it goes, another point in favour, being a character which can no longer be used as an argument to prove that the Pterodactyles were non-avian.

The skull, the microscopic structure of the teeth, and all the important bones of the skeleton, notably those of the fore-limb, have been subjected to minute examination and comparison with the corresponding parts in various birds and reptiles; and the points in which they most resemble either the one or the other are discussed and amply dilated upon; but upon this portion of the subject we cannot enter further than to summarize a few of the conclusions derived from the study of these remains. With regard to the skull, it is observed, "Every point of the Ornithosaurian skull upon which I have not offered comment presents absolute identity with the corresponding structures in birds"; and of the sacrum, that it is "distinct from that of birds, and yet altogether unlike the sacrum of any reptile." That "the pectoral and sternal bones are about as markedly avian as in the skull." That "the pelvis and hind limb are the least reptilian portions of the Ornithosaurian skeleton," that "the femur is in no respect a reptilian bone," and that the tibia and fibula are altogether avian, so much so that in many genera no anatomist could distinguish them from the same bones in birds."

These avian resemblances are not advanced by Mr. Seeley as original discoveries, for they have been noticed and commented upon by Herman von Meyer and others, but who have, notwithstanding these resemblances, referred them to the class reptilia.

Without committing ourselves to any opinion on the subject, we can, without hesitation, recommend those students who desire full information upon the many points advanced, from original observations and study, in support of the ornithic affinities of these interesting extinct animals, to read Mr. Seeley's paper. It is clearly written and argumentative, and is a valuable contribution to the literature of the Pterodactyles. W. D.

REPORTS AND PROCEEDINGS.

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GEOLOGICAL SOCIETY OF LONDON.—January 24th, 1877.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair. The following communications were read:—

1. "Note on the Question of the Glacial or Volcanic Origin of the Talchir Boulder-bed of India and the Karoo Boulder-bed of South Africa." By H. F. Blanford, Esq., F.G.S.

The author, referring to a doubt expressed by the President in a paper on Australian Tertiary Corals as to the glacial origin of the Talchir Boulder-bed, indicated the hypothesis of its formation by the action of local glaciers under present climatal conditions would require the elevation of the whole region to the extent of 14,000 or 15,000 feet, and the assumption that the denudation of this great mountain mass was so moderate that large tracts of the ancient surface are still preserved at levels now only a few hundred feet above the sea. This the author regarded as very improbable. He assumed that the President, rejecting the evidence adduced by various writers in favour of the glacial origin of the Talchír and Karoo Boulder-beds, was inclined to fall back upon the notion of their being of volcanic origin, and quoted a letter from Mr. King, who had described the Talchír rocks of Kámáram as trappean, in which that gentleman stated that the rocks so interpreted by him prove to be dark green and brownish mudstone. He cited further evidence of like nature, and concluded that the ascription of a volcanic origin to these boulder-beds was probably in all cases due to similar misinterpretations.

The President, having quitted the chair, stated that in the remarks he had made he had no wish to dogmatize, as the author seemed to think; and further, that those remarks were not made by him as President, but as a simple Fellow of the Society, in a paper written before he had the honour of filling the office of President. In connexion with the assumed improbability of a change of level to the extent of 14,000 or 15,000 feet, required, according to the author, by the hypothesis that the beds referred to were formed by local glaciers, he noticed that there was in the immediate neighbourhood of some of these deposits a fault with a downthrow of 12,000 feet, so that such changes were at all events not impossible. He remarked that as Professor at Cooper's Hill he had prepared an abstract of all that had been written on the geology of India, and in so doing had made a selection of the different views that had been expressed by Indian geological surveyors as to the nature of the beds in question, but found their opinions so strikingly divergent that he was forced to go back to the facts. He described the range of the great Talchír formation from the Sone river in the north to Hyderabad in the south-east and the Nerbudda in the north, and stated that throughout the whole region the plant-bearing series is underlain by crystalline rocks, except in one instance by Vindhyan rocks. The Coal-bearing series is found in basins or broken segments between great faults, the whole country, in fact, being much broken. The succession of the beds he described as follows:—At the top the Panchet beds, then the Barakar, and at the bottom the Talchir deposits about 500–800 feet thick, having as their lowest member a bed consisting of boulders united by a sandy silt. Towards the Nerbudda it was possible to trace within a few miles the source from which the blocks had been derived. The boulder-bed presented a close resemblance to an old shore-deposit, but to this might be objected the large size and angularity of the blocks, many of which must have travelled far, and some of which are scratched. The underlying rocks are sometimes grooved. The deposit occurs over an immense area, and its formation must have occupied much time, and some forces must have been at work to bring the blocks down and scratch them. Some Indian surveyors have referred their presence to the action of shore-ice. He maintained that scratching and angularity do not necessarily imply ice-action. With regard to the grooving of the underlying rock, he remarked that on rocky coasts instances are not uncommon of the production of grooves at right angles to the shore by tidal action and moving stones. In his opinion the deposits had been formed, as long ago suggested by Mr. Ball, by a combination of marine and land denudation, and he had certainly never suggested that they could be of volcanic origin. The so-called Karoo boulder-beds he thought are either brecciated traps or metamorphosed rocks into which the felspathic element largely enters.

2. "On British Cretaceous Patelloid Gasteropoda." By Joh Starkie Gardner, Esq., F.G.S.

In this paper the author commenced by a general statement as t the classification of the forms to be described in it, which he referre to the families Patellidæ, Fissurellidæ, Calyptræidæ, and Capulid He noticed thirty species, which are mostly of rare occurrence; an nineteen of these were described as new. Four genera we indicated as new to the Cretaceous series, and one as new to th Cretaceous in England. The new species were *Acmæa formosa* an *plana, Helcion Meyeri, Anisomyon vectis, Scurria calyptræiformis* an *depressa, Emarginula puncturella, divisiensis, ancistra, Meyeri,* an *unicostata, Puncturella antiqua, Calyptræa concentrica, Crepidu chamæformis, Crucibulum giganteum, Pileopsis neocomiensis, dubi* and *Seeleyi*, and *Hipponyx Dixoni*. Most of the Patellidæ we from the Neocomian, and the majority of the Fissurellidæ from th Upper Greensand; the species of the other two families were sca tered through the series. The author referred to the indications depth of deposit and other conditions furnished by these Mollusc and also to the resemblance presented by many of them to certa bivalves common in the same rocks, which he regarded as a sort mimicry.

3. "Observations on remains of the Mammoth and other Mamma from Northern Spain." By A. Leith Adams, Esq., M.B., F.R.S F.G.S.

The remains noticed in this paper were obtained by MM. O'Reil and Sullivan in a cavern discovered at about twelve metres from th surface, in the valley of Udias, near Santander, by a boring ma through limestone in search of calamine. They were found close a mound of soil which had fallen down a funnel at one end of th cavity, and more or less buried in a bed of calamine which cover the floor. The cavern was evidently an enlarged joint or roc fissure, into which the entire carcases, or else the living animal had been precipitated from time to time. The author had identifi among these remains numerous portions, including teeth, of *Eleph primigenius*, which is important as furnishing the first instan of the occurrence of that animal in Spain. He also recorded *B primigenius* and *Cervus elaphus* (?), and stated that MM. O'Reilly an Sullivan mention a long curved tooth which he thought might be canine of *Hippopotamus*.

Geologists' Association, University College, 5th Jan., 1877.—William Carruthers, Esq., F.R.S., F.G.S., President, in the Chair.

A paper was read by J. Starkie Gardner, Esq., F.G.S., "On the Bournemouth Leaf-Beds." The author described the nature of the operations in the Bournemouth Leaf-Beds which he has been carrying on for some years past, and explained that, having spent some time with the President, Mr. Carruthers, at Poole Harbour in the summer of 1876, he had been requested by him to give some account of this most interesting palæobotanical locality to the members of the Geologists' Association. Having given some general description of the locality, he said: If we examine these cliffs and banks, we find them composed of clays dark or white, or red and white mottled, of layers of coarse grey grit and of sands of every shade of red and yellow, white, and variegated. Often the sands have angular lumps of clay imbedded in them. The quarrying is mostly done in open pits, the clay being dug out perpendicularly with a long and narrow spade. Some of the deeper seams are mined, and a considerable depth is reached in Mr. Pike's workings, and at Branksea similar pipe-clay is worked under the sea-level.

Overlying the pipe-clays we find another series of deposits, which are not here quarried for use, but looked upon as refuse; but near Bournemouth they are dug into in many places for the brick-earth contained in them. They are easily distinguished by the darker colour and more sandy nature of the clays. These drab clay-basins are of smaller extent, and are full of remains of decayed leaves, and have actual seams of coal in them, which is burnt by the villagers. In the sheltered bay of Studland we can see but little of the cliffs, as they are now mostly overgrown to the very beach. One is struck, however, by the coloured sands, which forcibly remind those who are familiar with them of the still more brilliant hues of the sands at Alum Bay.

Being ferried across the inlet of Poole Harbour, and walking along the beach towards Bournemouth, we find the coast for the first mile composed of hills of blown sand, beyond which the cliffs we have been viewing from a distance rapidly rise. These cliffs are themselves of rather monotonous appearance, being devoid of the brilliant colouring so conspicuous at Alum and Studland Bays. Their colour varies from buff to white, and from white to slate colour. We notice apparently endless successions of clays, sands, and grits deposited at different angles, and without any single bed being traceable for more than a few yards. The cliffs, preserving the same characters for a distance of four miles, extend to near Boscombe, where we notice a change in their composition. The clays are black and still more sandy, the upper parts of the cliffs are far less steep and seem composed of loose white sands and shingle with a thick capping of gravel.

Still further to the east these beds disappear beneath the sea in consequence of the general dip of the strata. The sand beds which follow, where they cap the cliffs, are recognized from a distance by their greater slope from the cliff shorewards, for they are so loosely composed that every wind blows the sand away in clouds, and leaves the shingle to rattle down upon the beach. So loose is this material that that part of the coast-line which had cliffs composed of this sand has now but an insignificant height; the sand has been blown away by wind and wasted by rain, until the shingle has been left dropping lower and lower, and the stones which neither wind nor rain could affect have come closer and closer together. This is the cause of the land connecting Hengistbury Head being much lower than any other in the neighbourhood. The shingly beds are ancient sea-beaches, and their slope to the ancient sea can still be seen in places. So long have they been exposed that the flint pebbles in them are sometimes almost decomposed, the familiar white coating to the flints being an inch or more thick. This shingle, which is composed of rounded pebbles, that tell the tale of a long rolling on the old sea-beach, is now the source of the pebbles on the present beach, and the rounded condition of these pebbles on this part of the coast is not, as on the shore further towards Poole, or as at Brighton, the result of present wave-action, although the existing sea has undoubtedly reduced the pebbles in size. They cannot be confounded with the later angular river-gravels which everywhere cover this area.

At the peninsula of Hengistbury Head, about six miles beyond Bournemouth, the cliffs again rise, being at first composed of black, chocolate-coloured, and white sands with pebbles, and farther on of green clayey sands containing nodules of large irregularly-shaped concretions of sandy, argillaceous ironstone disposed in layers. Beyond Christchurch Harbour we have cliffs of white sand, which, according to my views, close the series.

Inland the country has a barren appearance except in the plantations, and the scattered brick-pits afford no additional information of use to us in our present researches.

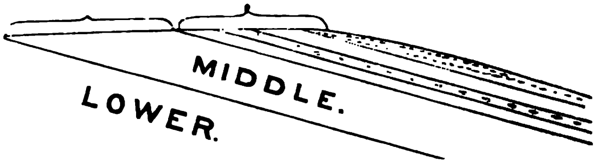


FIG. 1.

In the above rough diagram (Fig. 1) the lower fresh-water series is seen in the neighbourhood of Corfe, and forms part of the cliffs at Studland. It is marked by beds of pipe-clay, and has a thickness of 200 feet or more.

Near Corfe and Studland the middle fresh-water series is met with, forming the whole thickness of the cliffs between Poole Harbour and Bournemouth,—the section being four miles long and 100 feet high. Their entire thickness cannot yet be accurately stated, but may be put down at some 300 feet. They are characterized by the fact that the clays contained in them are usually brick-earth.

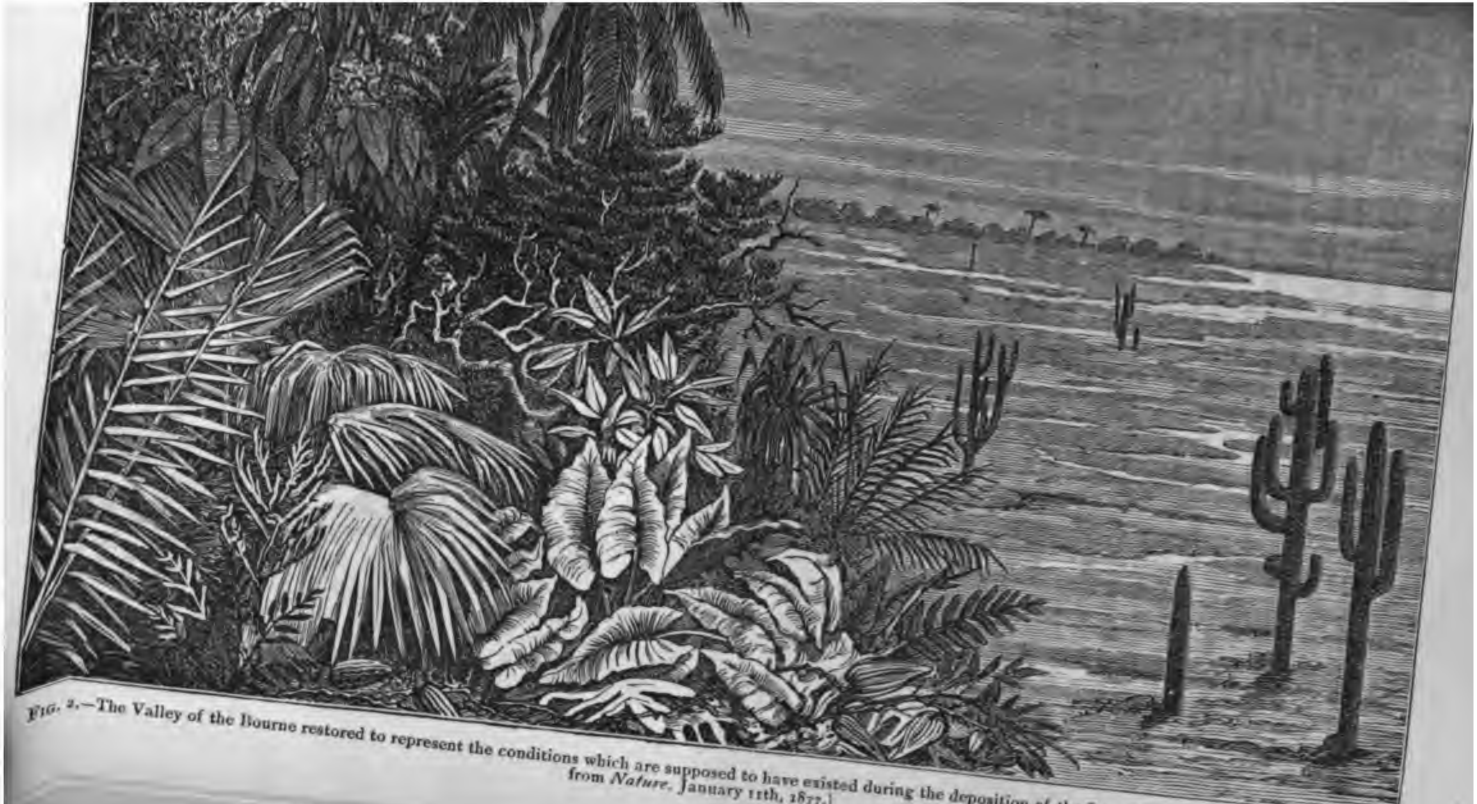
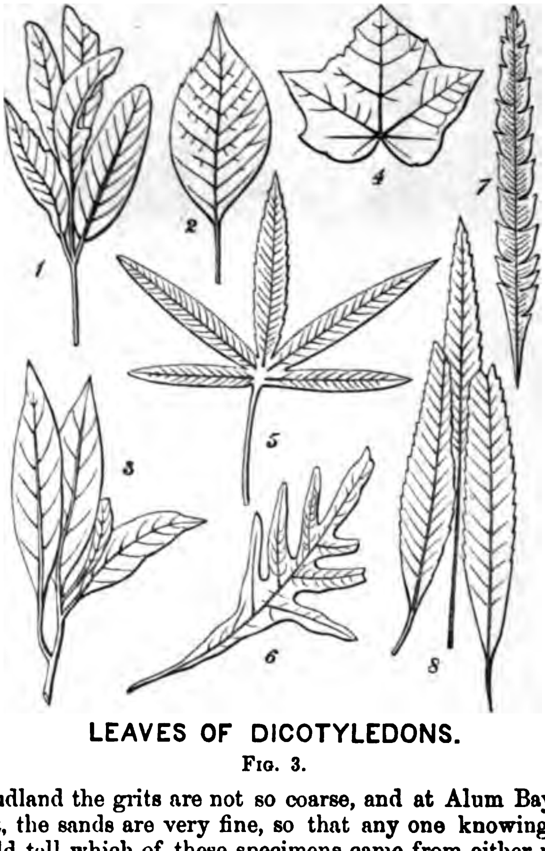


FIG. 2.—The Valley of the Bourne restored to represent the conditions which are supposed to have existed during the deposition of the Lower Bagshot F
from *Nature*, January 11th, 1877.]

The next series above is a marine series, and is some 400 or 500 feet thick. The base beds are dark sands and clays, succeeded by pebble-beds and sands, then more sandy clays with pebbles, and ending with a thick deposit of white sands. This marine portion of the series occupies the cliffs between Boscombe and High Cliff.

Plain as this order of deposition appears, we have collateral proof that this interpretation is right, for at Alum Bay there is a complete section of the whole of these beds, although somewhat thinned out, and upheaved vertically. We see in succession the lower pipe-clays, the brilliant sands, the darker clays, sands, pebble-beds, one after the other, and can examine them all in detail within the space of a few hundred yards.

The thick pipe-clays and quartzose grits which we find at the bottom of the series can without the slightest hesitation be referred to the result of the wearing away of granite rock.



LEAVES OF DICOTYLEDONS.

FIG. 3.

At Studland the grits are not so coarse, and at Alum Bay, a long way east, the sands are very fine, so that any one knowing the district could tell which of these specimens came from either place.

These clays extend under the surface, eastward, for they ar

ked at Branksea below the sea-level, at Parkstone, and near
ırne. At Alum Bay they are tilted up, and are full of beautiful
il leaves. (See Woodcuts Figs. 3 and 5.)

The series of beds above are of a different character, and
rk a great change in the conditions of the land, from a valley in
ich the previous beds were deposited, to a broad low-lying tract
proximity to the sea. We believe we can trace how this tract
came gradually lowered and lowered down to the sea-level.

The conclusion as to the gradual lowering of the land in this
ea is borne out by the fact that in the cliffs near Poole, which are
ghtly lower in position than those farther east, we get only leaves
evergreens and forest trees, whilst as we work our way east so
to meet with beds on a higher level, or, which is the same thing,
more recent age, we get a mixture of ferns and other plants,
ich require much moisture; whilst further east still we get assem-
ges of plants that could only have lived in absolute swamps.

Low as the land appears to have become, we have no evidence
atever, throughout the whole thickness of this part of the series,
ounting to 300 feet at least, with one exception, that it was low
ough to be inundated by the sea, as the few shells that have been
nd are of fresh-water kinds. The exception is the occurrence of
s of wood bored by the *Teredo.* All the ship-worms generally
own to us live only in salt water, and are so delicately organized
t the slightest mixture of fresh water instantly kills them. This
lated fact for some time presented a grave difficulty; but happen-
to read Mr. Gwyn Jeffreys' interesting account of the habits of
s creature, I not only found that he relates the occurrence of simi-
ly-bored wood 300 miles up the river Gambia, but distinctly
tes that there is a species which lives in fresh water. Therefore
s supposed marine indication may be on his authority removed,
l, supposing this theory should be verified and accepted, we may
ely infer that these middle beds are of fresh-water origin.

We now come to the third series of beds. A still continued sink-
of the area brought this swampy condition so low that the sea
s no longer kept out, but, bursting through, formed great salt-
ter lagoons teeming with life; for we suddenly find crowds of
rine forms imbedded in what was formerly black mud.

In this series of marine beds we have at the bottom lagoon beds,
I call them, indicating the former existence of mud-banks left dry
shallow between each returning tide. We still find here leaves
trees, many of them doubtless overhanging the lagoons, which
e so slowly decayed, that they are overgrown with *Polyzoa;*
wds of oysters are met with; we find the remains of shore-crabs,
ich overran the muddy shore; *Callianassæ,* which burrowed in
mud; *Calyptræa, Arca, Corbula,* and many other shell-bearing
llusca. This lagoon condition went on until the gradual sink-
permitted the ever-encroaching surf to break over the lagoon
rier, to rush in and overwhelm them with rolled shingle and sea-
d. We still trace the lagoon condition for a mile or so east,
ere it is represented by cigar-ash-coloured sands, impregnated

with salt, and coloured with the dark tint of carbonaceous matter. These sands contain very perfect remains of branches of a Coniferous tree resembling the genus *Dacridium* and large pieces of *Cactus.* It should be mentioned that this is the earliest cactus known, and that the spines are found to be still flexible. The sands are in other places crowded with fruits—probably a *Pandanus* fruit (*Nipadites*)—resembling those met with at Sheppey. Unfortunately the salt contained in them effloresces and splits all these specimens into fragments.

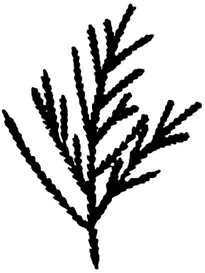
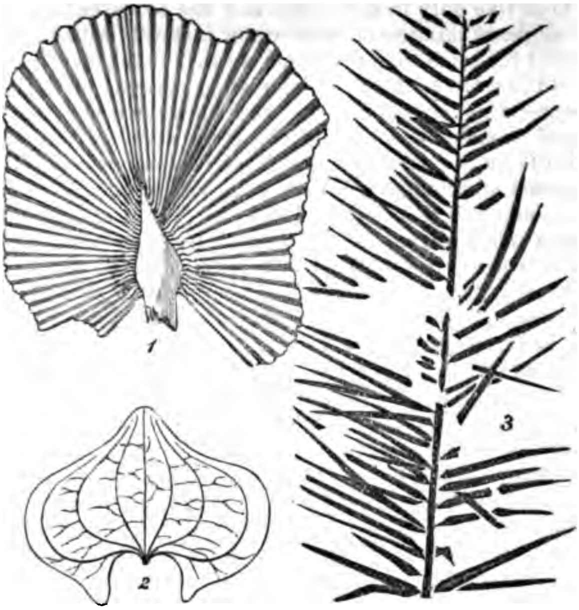


FIG. 4.—BRANCH OF CONIFER (*Taxodium*).



GROUP OF MONOCOTYLEDONS
FIG. 5.

At Hengistbury Head we have deeper sea-deposits, with sharks teeth and bones. At Highcliff, Barton, we have relics of a sea swarming with life, myriads of fossil shells may be collected from the cliffs, whilst still further on, at Hordwell, we have beds showing that the land arose again, affording suitable conditions for the growth of luxuriant palms, and was the haunt of the alligator, turtle, and other reptiles, which are now confined to tropical countries.[1]

CORRESPONDENCE.

THE OTOTARA SERIES, NEW ZEALAND.

SIR,—In the last received GEOLOGICAL MAGAZINE for August Capt. Hutton takes exception to my note appended to Mr. H. Woodward's paper on the "Fossil Crab of New Zealand."

One of his criticisms I admit to be correct. No distinct Saurian bones have been found on the West Coast. The error arose from an oversight in correcting the press, as the remark under letter *k* was (Saurian *beds*, Ammonites, etc.), by which I meant to indicate the horizon in the East Coast section of the same formation, as proved by associated fossils.

His other criticism relates to the presence of Secondary fossils in the Ototara group; but he evidently confounds this with his Oamaru formation, under which are included strata of both later and earlier date, while *localities* are excluded where Secondary fossils are found. Thus he places the Greensands of the Green Island Brown Coal in his Oamaru formation, although they contain *Belemnites*, *Ancyloceras Rostellaria*, and other Cretaceous forms. His Oamaru Cape beds I consider to be Miocene, while the Upper Marls at Amuri Bluff, which Capt. Hutton places in his Pareora or Miocene formation, are the calcareous Greensands that form the upper part of the Chalk formation, with *Inoceramus* and *Pleuronectes Zittelli*, the latter found ranging through the whole series; while from about the middle of the section the humerus of *Palæeudyptes antarcticus* has lately been found by Mr. McKay, making the third locality for this fossil bird in New Zealand. Other cases of stratigraphical confusion might be stated, showing that we have not yet acquired sufficient data for classifying our later formations by per-centages of fossils to the exclusion of stratigraphical evidence.

GEOLOGICAL SURVEY OFFICE, JAMES HECTOR.
WELLINGTON, 10*th Nov.*, 1876.

MR. MILNE ON FLOATING ICE.

SIR,—I am sorry that Mr. Milne should think that I made an "unfair comparison" in testing the behaviour of the floating cone he had figured, by means of a tetrahedron. "Comparisons are" always "odious." What then must they be when they are "unfair"? And I am the last who would wish intentionally to make unfair ones. The truth is that I had not a cone, and so I took the solid nearest in its proportions to Mr. Milne's figure, and I submit that the tetrahedron was quite as like an iceberg as the cone!

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[1] See also Report of Mr. Gardner's Lecture in the January Number of the GEOL. MAG. (p. 23), "On the *Tropical Forests* of Hampshire.

In Fig. 2 Mr. Milne has now shown us the highest cone which could float with its vertex upwards; and thereby proved that I was right in saying that a berg of the "shape" he had "figured" in his former paper "would not remain in that position, but must turn over."

Your readers will no doubt join with me in thanking Mr. Milne for his calculations, which I conceive may be thus summarized. If the

(1) Diameter of base of cone of ice is less than $\frac{2}{3}$ the height, it will float on its *side*.

(2) Diameter is greater than $\frac{2}{3}$ the height, it will float with its *vertex* downwards.

(3) Diameter is greater than *twice* the height, it *may* float with its *base* downwards.

(4) Or, since this case is included in (2), it *may* float with its *vertex* downwards.

However, when the diameter is only a little greater than twice the height, it would appear that the more stable position of the two would be with the vertex downwards. O. FISHER.

MODERN DENUDATION IN NORFOLK.

SIR,—The following facts concerning recent destruction of the Norfolk cliffs seem to be of sufficient interest to induce me to beg your insertion of them in your MAGAZINE.

On Tuesday, January 30th, we had a severe gale, which did much harm all along the coast. The coincidence of a spring-tide and a high wind from the W.N.W., brought the sea to a height it has not been known to reach for at least forty years. I have examined the coast from Hasborough to beyond Sherringham, and the damage done is marvellous. Probably the loss of land along the whole line of coast mentioned may be estimated at a yard. At the life-boat gap Bacton the amount that has gone is fifteen yards, and a strip o about that width is missing as far as the Walcot gap (three furlongs) At Bacton the cliffs are low, so the denudation is greater than in other parts.

Mundesley has had part of the life-boat gangway swept away, an some walls thrown down, besides the land lost.

At Cromer people are congratulating themselves on the smal amount of damage done; it is said that £150 will cover it. Durin the gale it was thought that the jetty would be pulled up bodily b the upward force of the waves; but fortunately the planks gave way and there are only about fifty missing. The gangway at the nort end of the town has been swept away; but as it was only made o earth, that will not much matter.

The most serious loss is at Lower Sherringham. There Mr Upscher has lost two acres; nearly all the sea-wall has been swep away: none of the gangways are left; a cottage and a shed hav fallen into the sea; the inn on the cliffs has had the windows broken and is in a very unsafe condition; and should another gale occu now, much of the village will go.

eybourn I hear that the sea broke through the beach and :he Coastguards' cottages.

of the fishermen can remember a *single* tide doing so much [believe a yard is rather more than the estimated yearly loss And Mr. Upscher informs me that he reckons his loss of ·ing the past sixty years to be thirty acres at the very least.

ICAL SURVEY, CROMER, CLEMENT REID.
th February, 1877.

THE TROPICAL FORESTS OF HAMPSHIRE.

-I have no wish to enter into any discussion with Mr. Searles jun.; but he has, it seems to me, written to you upon a on which, notwithstanding his large store of geological ge, he appears to be quite unacquainted. The supposition, to in my lecture at South Kensington, that oscillations of might partly account for the varied character of the Bagshot s partly based upon and supported by strong negative and sitive evidence, of alternating warmer and colder conditions, *al*; contained not only in English Eocene, but all Tertiary beds ›ut the world, although these seem to have escaped Mr. Wood's tion. No glacial conditions are necessary to explain anynnected with the Eocene Floras; but Mr. Wood cannot surely that the Bagshot leaves from the London basin and those urnemouth and Alum Bay indicate an equal temperature; or Fauna of the Thanet sands, Woolwich beds, and London · the Bracklesham, Headon, Bembridge, and Hempstead not make plain to us that the climatal conditions during sition of our Eocene series differed widely at each period. econd hypothesis, that of the existence of a mean annual :ure which permitted the growth of sub-tropical and more e forms side by side, is supported by abundant evidence, and ne by which Ettingshausen, and almost every continental ; who has devoted himself to the study of Tertiary Floras, explain the universal admixture of these forms at that time ır, *at present*, temperate climates. Mr. Searles V. Wood, wever, states that both these theories are "remote from the ınd proceeds to make some extraordinary mis-statements ·ocess of giving what he believes to be the true explanation. ‹pressing the total thickness of these beds, which reach 000 feet, as "upwards of 200[1] feet," he goes on to say that table remains have been drifted, and are *not in sitû.*

Vood can never have personally worked at these beds, or ımined collections made from them by others, or he could so failed to comprehend what he had seen.

›pears not to be at all aware of the published work and the ›ns of those who have studied these beds in England, or the .eaf-bearing Eocene and Miocene beds abroad; neither can heard or read the statements made by me in my lecture, or pendix to it communicated to the Geologists' Association.

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ras a Printer's error; Mr. Searles V. Wood, jun., correctly stated the .t 2000 feet, see his letter at *p.* 141. We regret the mistake exceedingly. *L. MAG.*

The leaves have never been drifted from afar; they are often still adhering to the twigs. The leaves are flat and perfect, rarely even rolled and crumpled, as dry leaves may be, if falling on a muddy surface; still more rarely have they fallen edgeways and been imbedded vertically. They are, moreover, not variously mixed, as they should be if they had been carried for any distance, but are found in local groups of species. For example, all the leaves of *Castanea* have been found in one clay patch, with *Iriartea* and *Gleichenia;* none of these have been found elsewhere. A trilobed leaf is peculiar to Studland; the Alum Bay *Aralia*, the peculiar form of *Proteaceæ*, the great *Ficus*, and other leaves occur at Alum Bay only. Each little patch at Bournemouth is characterized by its own peculiar leaves. Such a distribution can only result from the proximity of the trees from which the leaves have fallen. The forms of most temperate aspect are best preserved, so that, to be logically applied, the Drift theory requires the palms, etc., to have been drifted upwards. To suppose that most delicate leaves could have been brought by torrents 400 miles from Mull or 200 miles from Wales, and spread out horizontally in thousands, without crease or crumple, on the coast of Hampshire, may be a feasible theory to Mr. Searles V. Wood, jun., but will not recommend itself to the majority of thinkers. But without invoking these lengthy voyages, the requisite height might have existed near at hand in the granite region of Devon, during the Eocene time. However this may be, so obviously simple an explanation as that the temperate forms grew on high ground and were drifted down and mingled with those growing on lower levels, had of course escaped no worker on these or similar floras, and has been duly considered and abandoned by every one. J. S. Gardner.

IS THERE A BASE TO THE CARBONIFEROUS ROCKS IN TEESDALE?

Sir,—Some years ago, when out on a geological tour, I crossed over the Pennine Chain from Appleby, in Westmoreland, to High Force in Upper Teesdale. My route was first along the Eden valley plain to High Cup Gill Beck; next up the side of this Gill to High Cup Nick, at the head of the Beck; thence across to Maize Beck, which is a tributary to the Tees, following down the south side of this beck to Caldron Snout, and continuing on from here down the side of the Tees to the old Pencil Mill, where my attention was arrested by observing the shale, here exposed, to have a striking resemblance to the Silurian shales which I had noticed at the foot of High Cup Gill, on the other side of the chain, and at other places in the Lake District, also on the east side of this district, in Wastdale Beck, near Shap Wells. The Carboniferous strata rise from the vicinity of the old Pencil Mill, in a westerly direction, on the line of the route just sketched, and crop out on the west slope of the chain in High Cup Gill Beck, where there is to be met with one of the finest sections of the Carboniferous rocks in the North of England. In the lower part of this Gill there is a very thick section of rian rock exposed. The north side of Murton Pike forms the h side of the Gill here, and is almost entirely Silurian rock; ed, the west side of this Pike is wholly Silurian up to its sum- . Next, further up the Gill, is the Old Red Sandstone. Then higher up occur the escarpments of the alternating limestones, dstones, and shales of the Carboniferous series, including the lmerby Scar Limestone, which is the thickest bed of limestone on part of the chain. Above this series, at the head of the Gill, we e to the Whin Sill, where a considerable quantity of its débris at its foot. More Carboniferous rocks take on above the Whin l, and slope backward each way to form the summit of the ridge the north and south sides of the Nick. As to the thickness of strata from the base of the Carboniferous rocks, in this section, the bottom of the Whin Sill, I cannot do more than give a pro- le estimate, and will venture to put it down at about 1000 feet. uld this thickness be near the truth, as I expect it may, and if same thickness, or nearly so, occurs from the base of the Car- iferous rocks to the bottom of the Whin Sill, at the old Pencil ll, then, I think it may be fairly concluded that, the Silurian-like le, at this place, is not real Silurian, but indurated carboniferous le, and, therefore, the base of the Carboniferous rocks must be siderably below the bottom of the valley of the Tees at either loon Clints or the old Pencil Mill. The section at High Force, ut two miles further down the Tees from this place, affords litional evidence, corroborative of the soundness of the conclusion, t the base of the Carboniferous rocks cannot be seen in Teesdale. ay here refer Mr. Dakyns, or any of your readers, to that brief tract of a paper on this section, by C. T. Clough, Esq., B.A., G.S., in the GEOLOGICAL MAGAZINE for October, 1876, page 474.

Before leaving the subject, I may, however, state that there is a sibility of some peculiar positions of the strata, such as a great ward bend, or the upcast of a considerable dislocation, bringing base of the rocks in question to view. The Burtree Ford dyke a course nearly north and south; it ranges up the east Allen to west of Allenheads, thence through Weardale, at Burtree Ford; Mr. Forster, in his section of the strata, states that it crosses the es at Cronkley Scars. In Weardale this dyke brings rocks up view, which would not have been seen, had the dyke not existed. There is some probability that it might produce a similar effect ere it crosses through Teesdale; but whether it does so or not, ll be known by those who are better acquainted with the rocks that part of Teesdale than I am. JOHN CURRY.

OLTSBURN, EASTGATE, DARLINGTON,
February 5th, 1877.

THERE A BASE TO THE CARBONIFEROUS ROCKS IN TEESDALE?

IR,—My friend Mr. Dakyns, in the last Number of your MAGAZIZE, s the question, "Is there a base to the Carboniferous rocks in esdale?" Permit me, on behalf of my colleague Mr. Clough and myself, to answer the question in the affirmative. We cannot now give the reasons for our opinion, all details being reserved for a paper in preparation. W. GUNN.

GEOLOGICAL SURVEY OF ENGLAND AND WALES.
BARNARD CASTLE, *February* 16*th*, 1877.

BASE OF THE CARBONIFEROUS ROCKS IN TEESDALE.

SIR,—I have just opened Phillips' Geology of Yorkshire, Part 2, by chance at page 81: and the first words that caught my eye were "Widdybank" and "anomalous breccia."

This is the breccia which, on my visit to Teesdale, last October and November, I suggested to my companions, Messrs. Gunn and Clough, was the *base of the Carboniferous rocks*, for the reasons quoted by me in the GEOL. MAG. for February. From the use of the term "anomalous," it is clear that Phillips had noticed the peculiar character of the bed. It is somewhat strange that none of the geologists, as far as I know, who have written about the rocks in Teesdale, should have been struck with the possibility of the breccia being the base of the Carboniferous. They seem to have been too much taken up with the Whin Sill to think about that. Perhaps they did not see the Silurian-like dykes and pencil-beds below Cronkley; but if they did, they must have equally missed their suggestive character.

It is some satisfaction to us youngsters that the older geologists have left us something to discover. J. R. DAKYNS.

KENDAL, *February* 20*th*, 1877.

"KAMES" AND DENUDATION.

SIR,—Mr. Mackintosh is quite right. I have not seen either the English or Welsh 'Eskers' he mentions, so that perhaps, as another critic of my paper has said, I am "not entitled to generalize." But at the same time I cannot help expressing my astonishment at being told that there are vast numbers of Kames, or similar gravelly mounds, whose shapes have nothing to do with denudation. Since many of these mounds were first exposed to atmospheric influences, not only have rivers cut their channels to great depths through the most compact rocks, but the hard metamorphic mountains of the Highlands have been so wasted that their flanks are usually draped with debris, which, spreading over the floors of the valleys, bury them deep under masses of angular rock fragments, which are frequently shaped into very good imitations of Kames by the action of streams running along the valleys, aided by torrents from the mountain-sides. I do not suppose that any one would maintain that the shapes of these mountains have nothing to do with denuding agencies. How is it then that the loose gravels of the Kames "sometimes on the summits of hills," as Mr. Mackintosh says, have withstood influences before which the solid hills literally "flow from form to form"?

That the Newport Kames do not enjoy such immunity from the action of the rain-fall, has been demonstrated during the recent excessively wet weather. All the mounds not protected by grass have water-courses cut in their sides, some of them of considerable size. One stream, after leaping in a cascade from a hollow in a hill-side, has cleared out a channel of from eight to ten feet deep, and in some parts fifteen to eighteen broad. The loose gravelly sides of such channels soon fall in, and beyond a modification of the contour of the slope, all trace of the denuding agent is lost.

JAMES DURHAM.

P.S.—I heartily concur in Mr. Mackintosh's estimate of Mr. H. B. Woodward's admirable Geology of England and Wales, but Mr. Woodward says little about 'Kames' which would not be explained as readily by the Denudation theory as by any other.—J.D.

THE TROPICAL FORESTS OF HAMPSHIRE.

SIR,—Please correct the following *erratum* in the last Number of the GEOL. MAG. in my letter, line 3, from top of page 96; *for* "200 feet" *read* "2000 feet." That is the thickness of the Eocene beds in section in Hampshire, according to the Geological Survey Memoir by Messrs. Forbes and Bristow. It was written *very plainly* in figures in the MS. of my letter.

MARTLESHAM, NEAR WOODBRIDGE, SEARLES V. WOOD, JUN.
February 21*st*, 1877.

OBITUARY.

SARTORIUS VON WALTERSHAUSEN.

BORN 17 DEC., 1809. DIED 16 OCT., 1876.

THE death is announced of Professor Sartorius von Waltershausen, of Göttingen, on the 16th of last October, after a long and painful illness. The loss of a man who has done so much to advance the science of Petrology will be generally felt and deeply regretted. The obituary notice which has appeared in the *Jahrbuch für Mineralogie* is so singularly meagre that we propose to review in somewhat fuller detail his history and scientific labours.

Wolfgang Sartorius von Waltershausen was born on the 17th December, 1809. He was an illustrious son of an illustrious father, Georg Sartorius von Waltershausen, who was Professor of Philosophy in the University of Göttingen. The father was a great friend of Goethe, and was more especially known as the author of the "Geschichte des Hanseatischen Bundes." The son, after having taught for a time in some of the German schools of learning, and having published some memoirs on terrestrial magnetism, devoted several years to travel. From 1834 to 1846 he visited various districts, where the phenomena of volcanic activity could be studied with advantage, and the observations made in the field formed the material for more important memoirs issued in later years. He was for a considerable period in Sicily, returning in 1843, and his "Atlas" of researches on the rocks of Etna appeared three years later. In 1845 he visited Ireland and Scotland, and in 1846 we find him in Norway and Iceland. In the journey to the Danish Island he was accompanied by his friend Bunsen, and the results of the investigation of the igneous rocks, geysers and gases of that remarkable region have long been famous. In the same year appeared his paper on the submarine volcano of Val di Noto; while his riper reflections appeared in a memoir on the volcanic rocks of Sicily and Iceland in 1853.

In 1865 he published his views respecting the causes of the change of climate since the commencement of what has been termed the Historic period, and expressed his belief that the interval known as the Ice Age was due to an alteration of the contour of the earth's surface since Diluvial times. His labours, however, were not restricted to the field of Petrology. In 1856 he described what he regarded as a new mineral species from Borgarfiord, parastilbite, differing from epistilbite in some of its angular measurements; and he published about the same time his examination of the crystalline form of boron. In Palæontology, again, we find him actively at work; he described a fragment of a Saurian from the Coal-beds at Zwickau, and that of a fossil snake from Burlington, in Mississippi. It should be stated, moreover, that he was the close friend and ally of Gauss, and wrote the life of this eminent physicist and mathematician, which appeared at Gotha in 1856.

While so ably filling the position of Professor of Mineralogy and Geology in the University of Göttingen, he devoted himself to writing a *magnum opus* on Etna, which occupied him till a short time before his lamented death. The Chair which after the lapse of thirty years now becomes vacant has, it is stated, been offered to Prof. Tschermak, of Vienna.—W. F.

FIELDING B. MEEK,

PALÆONTOLOGIST, U.S.A.

BORN 10 DEC., 1817. DIED 22 DEC., 1876.

MR. F. B. MEEK was born in the city of Madison, Indiana, U.S. America, Dec. 10th, 1817. His grandparents were Irish Presbyterians, and emigrated to America from the county of Armagh, Ireland, about the year 1768. He spent his early days in Madison, where his father was a lawyer of considerable eminence: but unfortunately died when young Meek was only three years old, leaving his family in very moderate circumstances. From his earliest recollection he was interested in the Silurian fossils so abundant in the rocks of the neighbourhood of his home. He had never heard of Geology, but studied these remains with admiration and wonder as to their origin. On attaining his majority, by the advice of his friends, but against his own wishes, he commenced business as a merchant; but, absorbed in his favourite pursuit, he neglected his avocation, and in the financial crisis of 1847 he lost his small capital, on which he depended.

In 1848 he seems to have really commenced his career as a scientific man, being first employed as assistant to Dr. D. D. Owen, on the States Geological Surveys of Iowa, Wisconsin, and Minnesota.

In 1852 he became the assistant of Prof. James Hall, the eminent palæontologist of Albany, New York. Here he remained until

8, with the exception of three summers, two of which he spent n the Missouri State Geological Survey. In the summer of 1853 accompanied Dr. F. V. Hayden in an expedition to explore the ad Lands" of Dakota, and brought back very valuable collections. is was the commencement of that long series of successful ex- rations of all portions of the West, which have continued up to present time. While at Albany he was constantly engaged in most important palæontological works, the results of which were blished in the proceedings of the learned societies of the United ates.

In 1858 he went to Washington, where he resided until the time his death, leaving the city only for a few months at a time while gaged as Palæontologist for the State of Illinois, Ohio, or in field plorations in the far west, in connexion with the U.S. Geological rvey of the Territories under the direction of Dr. F. V. Hayden.

His publications, aside from the State reports referred to, were ry numerous, and bore the stamp of the most faithful and con- ientious research. One great distinction between Mr. Meek's læontological labours and the geological publications of his col- agues on the great Surveys of the States, lies in the fact, that hereas much of their work will require most careful concordance fore the grand results accomplished by them can be fully corre- ted, on account of many of the separate States having adopted rely local or new-coined names for their rock series, Mr. Meek's læontological work is at once available to his brother-workers all er the world, being written in the same cosmopolitan language.

Mr. Meek was so modest and retiring that he was scarcely known tside a very limited circle of friends. His bodily infirmities pre- nted him from mingling in society. Although his fame as one the most eminent palæontologists on the American Continent d been acknowledged among scientific men everywhere, his istence was scarcely known to the world at large. He was a ember of the National Academy of Sciences of the United States, d many other prominent scientific associations in America and Europe.

He died within the walls of the Smithsonian Institution, where had occupied rooms for eighteen years. He had been connected ith the U.S. Geological and Geographical Surveys of the Territories a salaried officer for the greater portion of the time since its first ganization in 1867.

His last great work (Vol. IX.) appeared in 1876, and contains 0 pp. of quarto text, and 45 plates, of which he writes to Dr. V. Hayden, "The following is my final Report on the Invertebrate retaceous and Tertiary Fossils of the Upper Missouri Country."

His grand palæontological works are his noblest and best monu- ent; yet, as Prof. Dana truly observes, "he is gone before his work as done;" and he adds, "American palæontology has lost (as regards Invertebrate Department) half its working force at a blow."[1]

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[1] These notes were, in great part, communicated by Dr. F. V. Hayden through e kindness of Thomas Davidson, Esq., F.R.S.—Edit. Geol. Mag.

HUMPHRY SALWEY.

BORN 1803. DIED 1877.

MR. HUMPHRY SALWEY, who died on January the 21st, at his residence, The Cliff, Ludlow, was one of the earliest pioneers of geological research in the Old Red Sandstone and Silurian districts; and he has formed an important collection of the fossils of the counties of Shropshire and Herefordshire, including many unique specimens. He derived his knowledge almost exclusively from observation, but he did not neglect the recorded observations of others, and his broad views and clear thought were most conspicuously displayed when, in the course of a day's work in the field, he would offer some friendly criticism of theories and conclusions which he could prove that less practical men had too readily admitted.

It was thus that Mr. Salwey did much valuable teaching, and not a few of his numerous geological friends will be ready to admit that he has given them standpoints from which the vision could penetrate the obscurity in which the geology of a district had been involved by too hasty generalization.

Mr. Salwey's knowledge of the local geology of his native district was such as can only be obtained by life-long labour. Those who knew him well have cause to lament the loss of a sincere and warm-hearted friend; but the geologist from afar, to whom he was always ready to extend a cordial welcome, will sustain a loss which cannot easily be replaced—that of an experienced and sound expositor of the typical Ludlow district. It was here that he delighted to welcome his fellow-workers, and to offer to them his open and unassuming hospitality: and the cordial welcome with which he and his family received the members of the Geologists' Association at The Cliff on the occasion of their visit to Ludlow in 1872, will ever be gratefully remembered by those who were present, several of whom have kept up the acquaintance then for the first time formed, and have revisited more than once the beautiful neighbourhood, replete with geological interest, then for the first time seen.

Mr. Salwey was one of the founders of the Ludlow Museum, which he has enriched with many valuable geological specimens. He has discovered several new species of fossils, principally collected in the Old Red Sandstone and the Ludlow Rocks, and his name as a palæozoic geologist is perpetuated in several species;[1] but he was not a writer, and, excepting in a few addresses to the Field Clubs of the neighbouring counties, his extensive knowledge of the geology of his district now, alas! lives only in the memory of those to whom he was so ready to impart it, or is diffused in their writings.—J. H.

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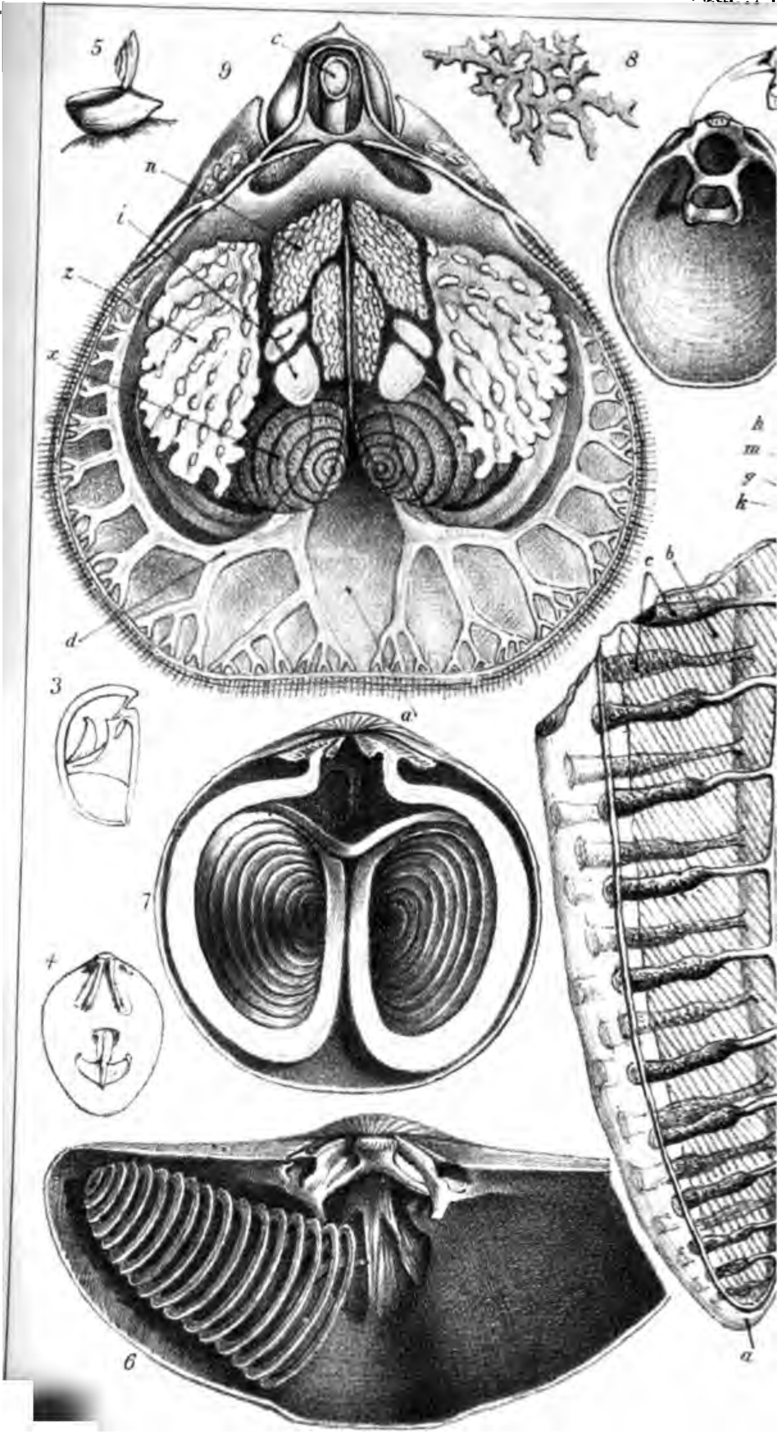
[1] *Zenaspis Salweyi*, Egerton; *Necrogammarus Salweyi*, H. Woodward; and *Monograptus Salweyi*, Hopkinson.



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THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. IV.

No. IV.—APRIL, 1877.

ORIGINAL ARTICLES.

I.—WHAT IS A BRACHIOPOD?[1]

By THOMAS DAVIDSON, F.R.S., F.G.S., V.P.P.S., etc.

PART I.

(PLATES VII. AND VIII.[2])

WE are all aware that it is very often much easier to put a question than to obtain an entirely satisfactory answer, and I am consequently sorry to have to begin my few observations on a very extensive class or group of organisms, by stating that zoologists and comparative anatomists have not yet entirely agreed as to the exact position it should occupy among invertebrate animals.

The first species belonging to the class were imperfectly and quaintly described and figured by Fabio Columna as far back as 1606, and for many years were supposed to be referable to the genus *Anomia*, one of the *Lamellibranchiata*; but as was judiciously observed by Edward Forbes, "A close examination shows that there is no relationship between them, but only a resemblance through formal analogy." It is during the present century that the class itself has been worked out and understood, and this has been achieved after the most lengthened and persevering researches.

It will not be possible in a short article to enter upon a complete history of the progress made by science up to the present time with respect to the Brachiopoda. Suffice it to say, that many of the most eminent zoologists and palæontologists have materially contributed to our knowledge of the group, and I have devoted the best portion of my life to its elucidation. We may however observe that, previously to the present century, several naturalists had published notes of some interest upon the Brachiopoda, which have helped to bring the subject under the special notice of the more experienced malacologists of our time. In 1675, 1687, and 1688, Martini Lister published figures of a few recognizable species of Brachiopoda, and in particular of *Productus giganteus*. In 1696 Llhwyd proposed the name *Terebratula* for several of the shells that had previously been referred to *Anomia:* he also gave some good figures of several species of Brachiopoda found in the neighbourhood of Bath. In 1773 T. Pennant described and figured some of the soft parts of the animal of *Terebratulina caput-serpentis* (especially its brachial or labial appendages), and in 1774 Grundler gave a good description of the same appendages with enlarged illustrations. Again, in 1776 and 1791, Müller and Poli described the animal of *Crania* (their *Patella anomala* and *Criopus turbinata*) with some enlarged illustrations, in which the brachial appendages are correctly represented.[1] During that century many species of Brachiopoda both recent and fossil were described and figured by Linnæus, Bruguière, and others, but no attempt at classification was made.

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[1] This memoir is the substance of a lecture delivered by the author to the Brighton and Sussex Natural History Society on the 11th of February, 1875, and subsequently published in French with additions and plates in vol. x. of the Annales de la Société Malacologique de Belgique for 1876.

[2] Plates IX. and X. will accompany Part II.

Space unfortunately will not admit of my mentioning in detail the honoured names of all those who have so materially contributed to the knowledge we at present possess with reference to the Brachiopoda; but we must allude to Von Buch, Alcide d'Orbigny, Defrance, de Blainville, de Verneuil, S. P. Woodward, Gray, Deslongchamps, father and son, Sowerby, Barrande, de Koninck, King, Salter, E. Suess, M'Coy, Hall, Billings, Dall, Dalman, Fischer, Pander, Moore, Eichwald, Kutorga, Keyserling, Sandberger, Seguensa, Meek, etc. The names of the zoologists who have so ably worked out the anatomical and structural characters of the animal will be duly recorded in the sequel. Grundler, in 1774, seems, however, to have been the first to propose to create for the animals under notice a distinct class among the Mollusca.

Name.—The name BRACHIOPOD (*βραχιων*, an arm; *πούς*, *ποδος*, a foot) was proposed for the class by Cuvier in 1805, and Dumeril in 1809, and has since been very extensively adopted. In 1824 Blainville proposed as a substitute for Cuvier's name that of Palliobranchiata (*pallium*, a mantle; *branchiæ*, gills), on account of the respiratory system being combined with the mantle on which the vascular ramifications are distributed. This term has always been adopted by Prof. King, who perhaps has rightly objected to Cuvier's name, on the grounds that it is a misnomer; for the two variously curved and cirrated brachial or labial appendages, improperly designated as arms or feet, were subsequently found not to subserve the function of locomotive organs.

Shell.—Before alluding to the position the Brachiopod should occupy amongst the Invertebrata, we may at once observe that the animal is protected by a shell composed of two distinct valves; and that these valves are always, except in cases of malformation. equal-sided, but not equi-valved. The shell is likewise most beautiful in its endless shapes and variations; in some species it is thin, semi-transparent and glassy, in others massive; generally the shell is from a quarter of an inch to about four inches in size: but in certain species it attains nearly a foot in breadth by something less in length, as is the case with *Productus giganteus*. The valves are often very unequal in their respective thickness, as may be seen in *Productus Llangollensis* (Pl. VII. Fig. 27); *Davidsonia Verneuili* (Pl. VII. Fig. 26), etc.; and while the space allotted to the animal is very great in a number of species, as in *Terebratula sphæroidalis* (Pl. VII. Fig. 25), it is extremely small in many others, as *Strophomena* and *Leptæna* (Pl. VII. Fig. 28). The outer surface of many of the species presents the most exquisite sculpture, heightened by brilliant shades, stripes, or spots of green, red, yellow, and bluish-black.

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[1] A very remarkable paper by M. de Lamanon, "Sur les Térébratules ou Poulettes, et déscription d'une espece trouvée dans les mers de la Tartarie Orientale," was published in 1797 in vol. iv. of the Voyage de la Pérouse autour du monde. In this memoir, which appears to have been overlooked by all those who have treated of the same subject, the author describes as far as his knowledge permits the soft parts of the animal of a species of *Terebratella*.

The valves have been distinguished by various names, but those of *dorsal* and *ventral* are in more general use. The ventral valve is usually the larger, in many genera as *Terebratula* and *Rhynchonella*, it has a prominent beak, with a circular or otherwise shaped perforation or foramen at or near its extremity, partly completed by one or two plates termed a deltidium. Through the foramen passes a bundle of muscular fibres called the peduncle, by which the animal is in many species attached to sub-marine objects during at least a portion of its existence. It is, however, certain from the admirable researches of Prof. Morse that the embryo of some, if not of every species, swims most actively in every direction and turns abruptly about; but that in the fourth stage of its development it becomes *attached*, the peduncle widening at its end into a sucking disk. Other species show no indication of ever having been attached; while some that had been fixed by means of a peduncle during a part of their existence become detached at a more advanced stage of life, the opening for the peduncle becoming gradually cicatrized. Lastly, forms appear to have adhered to sub-marine objects by a larger or smaller portion of the surface of their ventral valve, or by spines (*Strophalosia*, etc.), during their entire life.

In external shape the valves are essentially symmetrical (differing in this respect from those of the *Lamellibranchiata*), so much so, that certain Brachiopod shells received the name of *Lampades* from some early naturalists; but while such may bear a kind of resemblance to an antique Etruscan lamp, by far the larger number in no way resemble one. The valves are either articulated by means of two curved teeth developed from the hinge-margin of the larger valve, and fitting into sockets in the corresponding part of the smaller one, or they are unarticulated, and kept in place by means of muscles especially provided for that purpose.

Having described the exterior of the shell, a few words may now be devoted to its interior. On the inner surface of both valves several well-defined muscular impressions are observable, which vary considerably in position and shape in different genera and species. They form either indentations of greater or lesser size and depth, or occur as variously shaped projections. In the *Trimerellidæ* some of the muscles are attached to a massive or vaulted platform ituated in the medio-longitudinal region of the posterior half or umbonal portion of both valves. In addition to these, there exists n the interior of the dorsal valve of some genera a variously modiied thin, calcified ribbon-shaped lamina or skeleton for the support [illegible] appendages: and so varied, yet con[illegible] species is this laminal apophysis that it has [illegible] characters in the creation of both recent [illegible] Pl. IX. Figs. 2, 7, 9). The apophysis, or loop, [illegible] extending in some genera to upwards of [illegible] the shell, but in others it is so short [illegible] a little beyond the hinge. In some [illegible] the hinge-plate, as in *Terebratula*, *Wald*[illegible] Pl. IX. Fig. 2[illegible] in others to a central longitudinal plate or [illegible] Pl. IX. Fig. [illegible] In certain families the apophysis presents [illegible] processes which nearly fill the interior of the [illegible] of the spires being either directed outwards towards [illegible] angles [illegible] Pl. VIII. Fig. 6), or placed horizontally [illegible] inwards and towards the centre of the [illegible] of the same valve, which they almost fill; the inner [illegible] are pressed together and flattened with their ter[illegible] near the centre of the bottom of the [illegible] Pl. VIII. Fig. 7). In the *Rhynchonellidæ* again it [illegible] shape of two short, slender, curved laminæ (Pl. IX. [illegible] while in many genera and even families, *Productidæ*, etc., [illegible] support for the labial appendages.

[illegible] pallial sinuses, and ovaries, generally leave such in[illegible] on the internal surface of the valves, in both recent and [illegible] and species, that they materially assist in determining [illegible] forms; and in addition, the brachial or [illegible] have indications of their presence and cha[illegible] by the shape of the calcified skeleton [illegible] greater or lesser extent.

[illegible] —The structure of the shell has been shown by [illegible] King, Dr. Gratiolet and others to be generally [illegible] Lamellibranchiata or Gasteropoda. Dr. [illegible] the shell structure with infinite care [illegible] that in the shell of the Brachiopoda. [illegible] between [illegible] and *inner* layers, either in [illegible] growth, which prevails among the ordinary [illegible] from the nature and form [illegible] in which it is extended, that the [illegible] shell corresponds with the outer [illegible] He adds that he has, however, [illegible] layer in recent *Terebratulæ*, within [illegible] shell, but confined only to a part [illegible] beyond it. In some families, [illegible] three divisions: the innermost

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[illegible] the loop in *Wald. cranium* [illegible] M[illegible]" published in the [illegible] Forhandlinger" for 1875, Mr. Herman [illegible] becomes modified with age, and he [illegible] a simple loop out of a compound one, [illegible] settled a complete connecting [illegible] will have to be examined, which has not [illegible] satisfaction.

and middle divisions, which constitute the entire thickness of the valve, are calcareous, with a prismatic or fibrous structure, while the outer division consists of a very thin membrane (Pl. VII. Fig. 29). The innermost and intermediate divisions are in some families traversed by minute tubular canals which pass from one surface to the other, for the most part in a vertical direction, and at tolerably regular intervals; but just before terminating, near the outer surface of the epidermis, their orifices suddenly become dilated; the lower half of the canals being often considerably smaller in diameter than the upper half. The canals are occupied by cœcal processes proceeding from the mantle, or the fleshy covering of the animal. Their functional nature is according to Dr. Carpenter branchial or subservient to respiration; but, as observed by Prof. King, the outer epidermis, which covers their expanded terminations, would seemingly prevent any communication between the surrounding sea-water and the mantle; so that it may be questioned whether they are at all connected with the respiratory function. In certain genera, such as *Rhynchonella*, there are no canals; the shell being found to consist of flattened prisms of considerable length, which lie parallel to one another with great regularity, and at a very acute angle to the surface of the valves. The shell substance of *Lingula* Prof. King believes to be also almost entirely composed of Keratode, with a subordinate portion of phosphatic calcareous matter.

The shell structure of *Lingula* and *Discina* has also been attentively studied by Dr. Gratiolet in his excellent memoir "Etudes anatomiques sur la *Lingula anatina*," 1860. Therein he mentions, that "the structure of the valves in the *Lingulidæ* appears at first sight to differ much from that of the *Terebratulidæ*, but a more attentive examination reveals analogies at first unsuspected. Two distinct elements exist in the shell of *Lingula*—the one corneous, and the other testaceous. They occur in thick layers alternating from the convex to the concave surface of the valves, commencing with a superficial corneous one. These layers are not, however, of equal thickness throughout. On the convex side the thickness of the horny layers is greater towards the outer surface of the shell, while on the visceral, or inner surface, the testaceous elements predominate. They are of especial thickness at the level of the posterior angle of the rhomb. The thick testaceous layers are separated by thin corneous ones which thin out at certain points. This arrangement gives an amount of opaqueness to the central portions of the valves, while the outer edges, where the horny substance predominates, are semi-transparent. The structure of the testaceous layers simulates that of the *Terebratulidæ;* they are crossed by numerous microscopic canals which are traversed by extremely delicate striæ, recalling the chains formed by the prismatic elements of the shell in *Terebratulidæ*. This description applies equally to *Discina*, but in these last the calcareous portion predominates greatly over the horny one."

Soft Parts of the Animal.—I must now allude to some of the soft parts of the animal, but it would require much more space than can be bestowed in this short article to do anything like justice to so difficult a subject. I am, however, truly happy to state that this important inquiry has been most ably and successfully elaborated during the last forty years by some of the most distinguished anatomists and naturalists of the period. To such men as Hancock,[1] Cuvier,[2] Owen,[3] Huxley,[4] Gratiolet,[5] Vogt,[6] Macdonald,[7] King, and others, we are indebted for an extensive series of dissections and observations which have defined, to a very considerable extent, what are the true characters of the Brachiopod; while some important researches elaborated by Steenstrup, Lacaze-Duthiers, Morse, Dr. Fritz Müller, Oscar Schmidt, McCrady, Kowalevsky, and others, have thrown much additional light upon the embryology and early stages of the group. Some differences in opinion, it is true, have been and are still entertained with respect to the exact function to be attributed to certain parts of the animal; but on all essential questions there is a pretty general agreement.

Before describing the various parts of the animal, it may be as well to mention that the Brachiopods have been divided by Bronn into two great groups, termed *Apygia* and *Pleuropygia*. Professor King, considering these to be inadmissible on certain grounds, substituted the name *Clistenterata* for the first group, on account of its including animals that are destitute of an anal aperture; and the term *Tretenterata* for the second, as it embraces animals provided with this opening. The former division contains species which have the valves articulated, as *Terebratula*, *Spirifer*, *Rhynchonella*, etc. The latter comprise species with non-articulated valves, as *Lingula*, *Discina*, etc.[8] Some very important modifications in the animal are connected with these two divisions, especially in what relates to the muscular system.

According to Morse the Brachiopods are reproduced by eggs, generally kidney-shaped and irregular, which are discharged from the anterior margin of the shell, and drop just beyond the pallial membrane, hanging in clusters from the setæ. Some uncertainty has prevailed as to whether there is a male and female individual.

two, three, or four lobes clothed with vibratile cilia; and before becoming attached swims, or whirls head foremost, by means of the vibratile cilia covering the body. Morse describes the gradual formation of the shell from its first stage of development to the adult condition. Lacaze-Duthiers also alludes to two and four eye-spots in the embryo of *Thecidium*, and states that the animal appears to be in some measure sensible to light. The mouth conducts by a narrow œsophagus to a simple stomach, which is surrounded by a large granulated liver. Owen's "hearts" have been found to be oviducts, while the true heart would, according to Huxley and Hancock, consist of a pyriform vesicle appended to the dorsal surface of the stomach; but Prof. Semper, who has described the animal of *Lingula* at considerable length, with especial reference to its vascular system, contends that the pyriform vesicle termed "a heart" does not represent that organ, that there is not the least vestige of vascular system connected with it, and consequently that the existence of a heart must be considered unproven. The digestive organs, viscera, as well as the muscles, which take up only a small place in the proximity of the beak, are separated from the great anterior cavity, and protected by a strong membrane, in the centre of which the mouth is situated. The nervous system consists of a principal ganglion, of no great size.

Mantle.—Both valves are lined by a delicate membrane termed the "pallium" or mantle; it secretes the shell, and is generally fringed with horny bristles or setæ (Pl. VIII. Figs. 9 and 10). It is composed of an outer and inner layer, between which are situated the blood-channels or lacunes. The mantle has been ably described by Hancock, and by E. Deslongchamps,[1] who observes "that all the internal parts of the shell are lined by the internal layer of the mantle, with the exception of the muscular impressions, or those portions where the muscles are inserted on the inner surface of the shell."

The outer layer closely lines the inner surface of the valves to which it adheres, and in those species in which the shell is traversed by canals there exists on the surface of the mantle facing the inner surface of the valves, corresponding short cylindrical membranous projections, or cæca, which insert themselves into the small tubular orifices that traverse the shell (Pl. VIII. Fig. 10 *c*). The cæcal prolongations do not exist in those genera such as *Rhynchonella* where the shell is deprived of tubular perforations. The inner layer is rather thicker than the outer one, and is covered with vibratile cilia. Between the two layers composing the mantle are situated the blood-channels or lacunæ. These vary in their dispositions or details in different genera, and as they project to some small extent, leave corresponding indentations on the inner surface of the shell, so that their shape and directions can, very often, be traced on fossil and extinct genera, as well as if the animal were still living, as may be seen in the numerous illustrations appended to my works on British and Foreign Brachiopoda.

There are usually four principal arterial trunks in each lobe of the

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[1] Recherches sur l'organisation du Manteau chez les Brachiopodes articulés, Caen, 1864, and to which the reader is referred for further details.

mantle; the two central ones run direct to the front, near to which they bifurcate, while the outer ones give off, at intervals, on the side facing the lateral margin of the valves, a series of branches which bifurcate several times, as may be seen in the figures here reproduced from Hancock's admirable work (Pl. VIII. Fig. 9, Pl. X. Fig. 4). That eminent zoologist observes that the inner lamina of the mantle, and more particularly that portion of it forming the floor of the great pallial sinuses, undoubtedly assist in purifying the blood.

In 1854, in his review of my Monograph on British Fossil Brachiopoda, Oscar Schmidt called attention to an important anatomical omission, namely, the existence of a vast number of microscopic flattened, calcareous, denticulated plates or spiculæ on certain parts of the surface of the mantle, which serve, no doubt, to stiffen the portions that contain them. It was, moreover remarked by Hancock, and afterwards by Deslongchamps, that these calcareous plates "are not spread over the entire surface of the mantle, but only over the large vascular sinuses, the arms, and the periviseral cavity." These spiculæ do not, however, appear to be present in every species, being totally absent in *Lingula*, *Rhynchonella*, etc.; but Deslongchamps again observes that, "after an examination of the genera *Kraussina*, *Terebratula*, *Terebratulina*, *Megerlia* and *Morrisia* (*Platidia*), we find a series in which the number and consistency of the calcareous portions increase in a very rapid manner, the spicules forming several layers, leading the observer by a series of gradations to the genus *Thecidium*, in which the spicules are soldered together, occupying the whole of the mantle, and incrusting it to such an extent that the mantle is no longer distinguishable from the shell itself. The mantle forms that calcareous mass, which equals in consistency the brachial appendages, a fact of which palæontologists have often, and in vain, sought the explanation."

The Brachial or Labial Appendages are a pair of singular organs eminently characteristic of the Brachiopoda. They are often, more correctly, termed *labial* appendages on account of each member being a prolongation of the lateral portion of the lips or margin of the mouth. The lamellibranchs, or conchifera, have analogous appendages, but very much less developed. They assume different shapes in different genera, and are supported, or otherwise, by the more or less complicated calcified skeleton already described. The brachial or labial appendages, whether they form a pair of long, bent, or spirally convoluted organs, occupy the larger portion of the cavity of the shell, in front of the visceral chamber; they therefore are mainly composed of a membranous tube fringed on one side with long flexible cirri (Pl. IX. Figs. 4, 5, 6), which were not capable of being protruded in those families and genera in which they were folded back upon themselves, and supported by a calcareous skeleton. In *Rhynchonella*, where the elongated spiral arms are only slightly supported at their origin by two short projecting calcareous processes, they could be unrolled at the will of the animal and protruded to [illegible] distance beyond the margins of the valves. When forcibly stretched out, they are said to be more than four times the length of the shell, and to support some 3000 cirri (Pl. IX. Fig. 8). It must, however, remain for ever uncertain whether in the extinct genera *Spirifera*, *Atrypa*, and others, in which the spirally coiled fleshy arms were supported throughout their entire length by a calcified skeleton, the animal could protrude its labial appendages beyond the margin of the valves.

In some families—*Rhynchonellidæ*, *Productidæ*, and others—these organs are spiral and separate; in others, *Lingulidæ*, only at their extremities. It is almost certain that these beautiful organs, by means of their cirri and the cilia they are doubtless furnished with, are not only instrumental in carrying floating nutrimental particles or minute microscopic organisms to the mouth (which is situated between the appendages at their origin); but are subservient to the function of respiration. Hancock observes that "to prove that the brachial organs subserve the function of gills, as well as that of sustentation, it is only necessary to refer to the manner in which the blood circles round the arms (labial appendages), and is carried to the cirri; but more particularly to its circulating through these latter organs, returning direct from them to the heart."

(*To be continued in our next Number.*)

EXPLANATION OF PLATE VII.

FIG.

1. *Terebratula septentrionalis.* A cluster of eggs from the genital band (magnified).
2. ——— Egg from the perivisceral chamber, immediately after their escape from the pallial sinuses.
3. ——— Egg; first ciliated stage.
4, 5. ——— Transverse division of embryo, showing long tuft of cilia at cephalic extremity.
6, 7, 8. ——— Embryo, showing various outlines assumed in, while swimming.
9, 10. ——— Embryos attaching themselves by their caudal segment.
11. ——— Embryo showing first appearance of caudal or peduncular segment.
12, 13, 14. ——— Successive changes of the embryo, showing formation of dorsal and ventral areas by the folding and growth of the thoracic ring.
15, 16. ——— Embryo, the deciduous setæ appear in this stage.
17. ——— Free swimming embryo.
18. ——— First stage, in which the mouth makes its appearance, and dorsal and ventral plates become distinctly marked.
19. ——— Earliest stage, showing arrangement of deciduous setæ, and contour of embryonic shell.
20. ——— A considerably advanced stage, showing subsequent widening of the anterior portion of the dorsal and ventral plates.

All the above enlaged figures are taken from Prof. Morse's memoir on the embryology of *Terebratulina*.

21. *Waldheimia cranium.* Showing the manner in which it attaches itself by the means of its peduncle. *a.* ventral; *b.* dorsal valve; *p.* peduncle.
22. *Discina lamellosa.* Showing the manner in which it attaches itself and forms clusters of large dimensions. Upwards of one hundred specimens thus attached were sent to me by Prof. Verrill, from Callao, Peru. *p.* peduncle.
23. *Crania ignabergensis* (fossil). Showing the manner in which it attaches itself to submarine rocks and corals by a portion of the surface of one of its valves.
24. *Chonetes striatella* (fossil). To show the row of hollow spines that rise from the upper edge of the area of the dorsal valve.
25. *Terebratula sphæroidalis* (fossil). Longitudinal section to show the loop and large free space for the occupation of the animal. *a.* ventral; *b.* dorsal valve.

26. *Davidsonia Verneuilii* (fossil). To show the great thickness of the ventral valve *a*, and its mode of attachment to submarine objects by a portion of the substance of this valve. *b*. dorsal valve; *d*. small free space left for the animal.
27. *Productus Llangollensis* (fossil). Longitudinal section to show the great difference in thickness of the valves. *a*. ventral; *b*. dorsal; *d*. space left for animal.
28. *Strophomena filosa* (fossil). To show the small space left for the animal between the valves.
29. *Waldheimia flavescens*. Enlarged section of shell (after King). *o*. thick calcareous innermost division; *n*. intermediate thin calcareous division; *m*. outer division of thin membrane; *e*. *f*. canals traversing the calcareous layers *o* and *n*; the lower half of the perforation being considerably smaller in diameter than the upper one.
30. *Terebratula bullata* (fossil). Section of shell near the external surface and parallel to it, showing the remarkably large size and close proximity of the perforations. 100 diameters.
31. *Waldheimia flavescens* or *australis*. Internal surface of the shell, showing the imbricated arrangement of the extremities of the prisms, which are seen longitudinally at *b*, magnified 100 diameters.
32. ———— Vertical section, considerably enlarged, so as to show the ordinary trumpet-like form of the vertical passages and remarkable condition which they exhibit in the inner and (probably) later-formed layer.
33. *Rhynchonella psittacea*. Portion of the internal surface of the shell more highly magnified, showing the imbricated arrangement and the entire absence of perforations, magnified 100 diameters.
34. ———— Portion of the shell, showing at *a* the internal surface, with the imbricated arrangement of the extremities of its component prisms, and at *b* the aspect of the prismatic substance as displayed by a fracture nearly in the direction of the length of the prisms, showing also entire absence of the least trace of perforations. Magnified 40 diameters. Figs. 30 to 34 after Dr. Carpenter.
35. *Lingula anatina*. Longitudinal section of the shell to show the alternation of calcareous and horny layers; *b*. *b*. calcareous layers perforated by minute canals; *d*. *d*. horny layers. After Dr. Gratiolet.
36. *Crania anomala* (enlarged). Interior of the dorsal valve to show the position of the spiral appendages. From a specimen in the Museum of the School of Mines.

FIG.

CLISTENTERATA. PLATE VIII.

1. *Terebratula carnea* (fossil). Interior of the dorsal valve, to show the short simple loop.
2. *Terebratulina caput-serpentis*. Interior of the dorsal valve, to show the ring-shaped loop.
3. *Magas pumilus* (fossil). Longitudinal section to show the large central septum and disunited deflected portion of the loop.
4. *Bouchardia tulipa*. Interior of the dorsal valve, to show the anchor-shaped apophysis.
5. *Thecidium mediterraneum*. Seen in profile. The valves opened as in life. After Lacaze-Duthiers.
6. *Spirifer Schrenkii* (fossil). Interior of the dorsal valve, showing the cardinal process, quadruple impression of the adductor muscle, and one of the calcareous spiral laminæ for the support of the labial appendages.
7. *Atrypa reticularis* (fossil). Interior of the dorsal valve, showing the position and shape of the spiral laminæ for the support of the labial appendages.
8. One of the spiculæ of the mantle of *Terebratulina caput-serpentis* highly mag.
9. *Rhynchonella psittacea* (after Hancock) much enlarged. Dorsal view of the animal; *a*. pallial lobe; *c*. peduncle; *d*. great pallial sinuses giving off branches at the margin; *i*. extremities of adductor muscle; *n*. liver; *x*. spiral brachial apparatus; *z*. genitalia and muscular ties uniting the walls of the genital sinuses.
10. *Waldheimia australis* (after Hancock). Diagram of longitudinal section of marginal portion of valves in connexion with the mantle, much magnified;

a. margin of valve; *b.* shell exhibiting prismatic structure; *c. c.* pallial cæca penetrating ditto; *d.* great pallial sinus; *e.* marginal vessels; *f.* outer lamina of mantle; *g.* external reticulated layer of ditto, in which the pallial cæca take their origin; *h.* homogeneous layer of other lamina; *i.* inner lamina of mantle; *j.* epithelium; *k. k.* membrane lining pallial sinus; *n.* inner ditto; *o.* marginal fold; *p.* one of the setæ; *q.* follicle of ditto; *r.* prolongation of glandular matter of follicle; *s.* marginal muscles; *t.* extreme pallial margin.

(*Plates* IX. *and* X. *will appear in our next Number.*)

–THE MAGNESIAN LIMESTONE AND NEW RED SANDSTONE IN THE NEIGHBOURHOOD OF NOTTINGHAM.

By W. T. AVELINE, F.G.S.,
Of the Geological Survey of England and Wales.

NCE the Government Geological Survey of the country around
Nottingham was made in the year 1859, and the Explanation
he Geological Map Quarter-sheet 71 N.E. was written in 1861,
ers by local geologists have been written, stating that in the
hbourhood of Nottingham a perfect conformity existed between
Magnesian Limestone and the New Red Sandstone. This being
lly at variance with conclusions I came to when I surveyed that
ntry, I have been for some time past desirous to say a word on
subject, but being deeply occupied with the old rocks of the Lake
rict, I have put it off from time to time. I felt little doubt in my
d, when surveying the neighbourhood of Nottingham, that there
a considerable break between the Magnesian Limestone and the
r Red Sandstone, and this opinion was completely confirmed as
ntinued my survey northwards through Nottinghamshire into
kshire. Unfortunately I did not make a statement regarding
break between the two formations in my Explanation on Sheet
N.E. Wishing to compress my observations as much as possible
orm a pamphlet, the price of which would not be more than six-
ce, much that might have been of interest was left out. But in
Explanation on Geological Map Sheet 82 N.E., the country
he neighbourhood of Worksop, I have given my proofs of this
t break. I have shown that in the district to the north of
rksop the Permian series consists of at least four divisions. To
in at the top, there are the Upper Marls; next below the Upper
nesian Limestone so-called, though it contains little or no Car-
ate of Magnesia; then the Middle Marls and Sandstones; and,
ly, the lowest and chief member of the Permian series, the Lower
nesian Limestone. I state that the Bunter Sandstone overlaps
Upper Permian Marls throughout most part of the district, and
re the neighbourhood of Worksop is reached the Upper Limestone
lso overlapped. From Worksop southward to Nottingham there
only left the Middle Marls and Lower Magnesian Limestone.
ween these two places the Middle Marls are frequently over-
ed, and, finally, west of Nottingham, the Lower Magnesian
estone is itself overlapped, the New Red Sandstone resting on
Coal-measures. Therefore, in the neighbourhood of Nottingham,
ead of there being a perfect conformity between the Magnesian

Limestone and the New Red Sandstone, and a passage from one into the other, there are at least three subdivisions wanting that should come between these formations.

I am quite willing to admit that there is a much greater degree of conformity between the Permian and the New Red Sandstone than between the Carboniferous and the Permian, and that the great division between the Primary and the Secondary formations should be at the bottom and not at the top of the Permian. The links that bound the Permian to the Carboniferous are now nearly all broken. The Lower Red Sandstone of Sedgwick, or Rothliegende of Murchison, lying below the Magnesian Limestone, with its coal-plants and even coal-beds, is now proved to be either Coal-measures or Millstone-grit, and the Permians of Staffordshire and Warwickshire are now said to be Upper Coal-measures of a red colour.

The relation between the Permian and the New Red Sandstone is an interesting question, but the truth can only be arrived at by a statement of facts. I have nowhere myself seen a passage upwards from the Permian into the New Red Sandstone, but I will not say such a thing does not occur.

III.—ON THE FIRST STAGES OF THE GLACIAL PERIOD IN NORFOLK AND SUFFOLK.

By THOMAS BELT, F.G.S.

THE publication in the last Quarterly Journal of the Geological Society of the most instructive paper by Messrs. S. V. Wood, jun., and F. W. Harmer, on the Later Tertiary Geology of East Anglia, and one by the latter author on the Kessingland Cliff-section, induces me to offer the following remarks, with the hope that my views may be considered by geologists who have made this question their study.

Messrs. Wood and Harmer show very clearly that over most of Norfolk and Suffolk, laminated brick-earths were originally spread out, and afterwards more or less denuded, and in some parts greatly contorted and disturbed. At their base lie pebbly sands, which are partly the "Westleton beds" of Mr. Prestwich, and above them lie the "Middle Glacial sands and gravels" of Mr. S. V. Wood, jun.

In nearly all the sections given by the authors in the above-named memoirs, and in most of those that I have myself examined, the brick-earths and pebbly sands rest directly on the Chalk or on the Newer Tertiary beds. In the few exceptions, as in the Cromer Cliff section, and near Thetford, where these brick-earths are underlain wholly or in part by till, there is much disturbance of the strata, and the beds are greatly contorted and folded, as has been very fully described by Sir Charles Lyell.

I have in various papers urged that the ice that flowed down the bed of the German Ocean reached to and invaded the coast o Norfolk; and it may very well have been reinforced by ice tha had rounded the southern end of the Pennine Chain from the north-west, as we know that it was of immense thickness in Lancashire.[1]

Now if the brick-earths had been deposited before the ice reached the coast, it seems not improbable that they should be contorted by it and pushed up by the rising ice, so that in some cases the till would be actually deposited below them. We find that the ice has certainly accomplished this with the Lias, the Kimmeridge-clay, and the Chalk, so that great masses of them are often found lying on till; and at the Ely Clay-pit there was a fine section open last summer, showing highly inclined beds of Chalk, Kimmeridge Clay, and Neocomian Sands, all underlain by till, and that by crushed and disturbed beds of Kimmeridge-clay.

Evidence of the passage of ice over the district has been found by Messrs. Wood and Harmer in the valley of the Yare, the Wensum, and the Little Ouse, and I have noticed it besides in the valleys of the Waveney and the Ouse.

I believe it was Mr. Croll who first pointed out that the bed of the North Sea between Scotland and Scandinavia had been filled with ice, and this opinion is now held by many geologists. In a letter to *Nature* in 1874, I remarked that, as up to the time of the Glacial period the Straits of Dover did not appear to have been cut through, it was evident that as soon as the northern end of the German Ocean was blocked up by ice, a lake must have been formed, which drained to the south-west, and gradually wore out a passage through the Straits of Dover. This has appeared to many a rash speculation; but if any one will take the trouble to imagine what would be the necessary result of stopping the flow of water to the north, before the passage to the English Channel was open, he will find that the theory is not an improbable one; and I am glad to see that it has been indorsed by Mr. Croll.[2]

At first, when the northern outlet was only partially obstructed, the water would still be salt, though not so much so as the open sea, and perhaps only stand a few feet above the present sea-level; but as the ice advanced, the water would rise until it overflowed the isthmus that then connected England with the Continent. The water of the lake would be fresh, or but slightly brackish, and I suppose it was then that the laminated brick-earths, including those of the lower part of the Thames Valley, were deposited. The Straits of Dover were gradually cut through, and the brick-earths denuded, whilst the ice from the north was slowly advancing southward. At last, I suppose, the ice reached the coast of Norfolk, forced up great masses of Chalk, and contorted and shifted the laminated brick-earths.

A branch of the ice-stream flowed up the Wash, and being re-inforced, as before mentioned, from the north-west, reached certainly as far south as Ely, and probably much further, sending off a branch along the depression now occupied by the valley of the Little Ouse and the Waveney. I suppose that the ice in passing along the sea-bed had become partly charged with marine remains, and that thu the broken shells were introduced that are found in some of th Norfolk drift.

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[1] Mr. R. H. Tiddeman, Quart. Journ. Geol. Soc. vol. xxviii. p. 471.

[2] Climate and Time, p. 452.

It will be readily seen that this is not a theory specially propose to account for the phenomena presented in the Norfolk and Suffol beds, but rather an attempt to show that they are naturally explaine by that of the German Ocean glacier, which rests upon other an very strong evidence. I have, during the last twelve months, discussed this question with several geologists acquainted with th district; and though I cannot say that I have made any converts, have only met with general objections, such as the unwillingness t admit that there was ever such an accumulation of ice as would fi the bed of the German Ocean; this feeling seeming to over-rid every evidence of its existence. It will, however, strike man minds, that in a theory so comprehensive as that which I have proposed to account for the varied phenomena of the Glacial perio there ought, if it is not the true one, to be many facts that cannot b explained by it. I am unable, either by my own observation or b studying the works of others, to find any; and I have thought tha by presenting clearly my theory in reference to one restricted are and to one portion only of the Glacial period, I should offer a fai opportunity to those who differ from me to bring forward the fact on which they rely. I have therefore confined these remarks to th question of the formation of the Quaternary beds of Norfolk an Suffolk, up to and including that of the Cromer till, but have n here dealt with the larger subjects of the Boulder-clays and Middl Glacial sands and gravels, of which, however, I have treate elsewhere.

Briefly, my conclusions respecting the beds in question are follows:—

1. The Cromer forest grew before the German Ocean had bee blocked up to the north by ice.
2. The fluvio-marine beds, lying above the forest bed and th pebbly sands at the base of the laminated brick-earths, were forme when the northern end of the German Ocean was partly obstructe so that the water was slightly freshened and a little raised above th present level of the sea.
3. The laminated brick-earths were deposited when the ice co pletely blocked up the German Ocean to the north, causing t formation of a lake that drained to the south-west and gradually c through the Straits of Dover. The water of this lake was fresh but slightly brackish.
4. The Straits of Dover were cut through, the lake lowered, an the brick-earths denuded, whilst the ice was advancing southwa along the bed of the German Ocean.
5. The ice reached the coast of Norfolk, and crumpled up an shifted the brick-earths that it came in contact with, and in so cases, as on the north coast of Norfolk, where its power was greate pushed them up and deposited till beneath them, as it did also wi great masses of Chalk-marl and Kimmeridge-clay.

IV.—NOTES ON THE GEOLOGY OF THE LEBANON.

By the Rev. E. R. LEWIS, M.A.,
Of the Syrian Protestant College, Beirût, Syria.

I HAVE been fortunate enough to obtain from the eastern slope of Mount Hermon (Jebel esh Shech) a large lot of fossils, which not only determine the geological position of that part of the Lebanon, but also settle the question of the existence of Jurassic formations in Syria. Of course it has been often enough asserted that Jurassic rocks are found here, but the fact has not been considered settled beyond doubt.

M. Louis Lartet, in his "Géologie de la Palestine," p. 120, says:—"Le *Cidaris glandifera* et le *Collyrites bicordata* sont les deux seuls fossiles jurassiques du Liban et de l'Anti-Liban dont l'authenticité soit jusqu'ici établie." M. Lartet evidently felt that Botta, Russegger, and others had been hasty, if not inaccurate, in their conclusions.

Dr. Oscar Fraas, of Stuttgart, in his "Aus dem Orient," p. 40, says that his chief object in visiting Syria was to determine "with what part of the Jura formation we have here to do," and adds, "denn dass in Palästina die Juraformation die Hauptgruppe der Gebirge bilde, war mir nach Allem, was ich an Literatur kannte, eine ausgemachte Sache."

Dr. Fraas, as a geologist who had been brought up among Jurassic formations, and therefore by M. L. Lartet styled "géologue jurassien," was without doubt competent to decide the question which he went to decide. He examined the geological formation of Palestine from Jaffa to the Dead Sea, and from Jerusalem to the Mountains of Galilee. and then wrote, "dass weder von älterer Kreide noch von Tertiär, geschweige von Juraformation oder sonst einem secundären Gebirge die Rede ist, glauben wir an der Hand leitender Fossile zur Genüge beweisen zu können," p. 72. He also writes, p. 71, that the formation which makes up the Lebanon is the same as that in the south. These late and trustworthy investigations of M. Louis Lartet and Dr. Oscar Fraas certainly left the existence of Jurassic formations a matter to be yet decided.

In the summer of 1873 I first found, on the eastern slope of Mount Hermon (at a place a little north of where M. Louis Lartet found specimens of *Collyrites bicordata*), a lot of fossils which differed from any I had hitherto found in the Lebanon. Dr. Fraas had never reached this place, I believe. Again, in 1874, I visited this place, and collected a large and exceedingly valuable set of fossils which I submitted to Dr. Fraas for determination. The following is the answer returned by him:—

Rhynchonella lacunosa, Buch.
Terebratula bisuffarcinata, Ziet.
Ammonites transversarius, Quenst.
——— *dentatus*, Rein.
——— *convolutus*, Schloth.
——— *flexicostatus*, Phillips.
Ammonites hecticus, Quenst.
——— *perarmatus*, Sow., d'Orb.
Nucula variabilis, Sow.
——— *ornata*, Quenst.
——— *lacryma*, Morr., Sow.
Belemnites semihastatus, Blainville.

Dr. Fraas adds to this list, "Vraiment oxfordien! tous des fossiles correspondent exactement aux fossiles du même horizont en Europe."

I have to add to the above that I visited the summit of Mount Hermon during the summer of 1875, and while there obtained from the live rock, near the highest point at Kasr Antar, a specimen of *Rhynchonella lacunosa.* The specimen was not perfect, but there could not be much doubt about what it was. It is evident then that we have at last obtained satisfactory evidence of the existence of Jurassic formations in Syria. The beds on the eastern slope of Mount Hermon are without doubt the White Jura and the Brown Jura of the Germans. These beds are examined at best advantage near Mejdel esh Shems, a small village about two hours north-east of Banias. The strata dip to the south-east and disappear under the Hauran basalt, which here reaches its limit. This Jura formation, however, does not seem to be limited to this place, but evidently reaches to the highest summit of Hermon, thus establishing the geological position of this mountain.

I have a large collection of these Jurassic fossils; but to Dr. Oscar Fraas, of Stuttgart, is due the credit of identifying them.

V.—ON BARON C. VON ETTINGSHAUSEN'S THEORY OF THE DEVELOPMENT OF VEGETATION ON THE EARTH.

By J. STARKIE GARDNER, F.G.S.

I. *Genetic relationship of the Tertiary Flora-elements*[1] *to the living Floras.*

[Aus dem LXIX. Bande. der Sitzb. der k. Akad. der Wissensch. I. Abth. März-Heft, 1874.]

BARON ETTINGSHAUSEN has forwarded to me from Graz a series of papers, relating more especially to the Fossil Floras of the Tertiary Periods. We have been made familiar with these mainly through the translations of the works of Heer, Unger, and De La Harpe; but to most of the readers of this Journal the work and opinions of other continental palæontologists, such as Ettingshausen, Massalongo, and Saporta, are unknown. It may, therefore, not be out of place, pending the contemplated publication by the Palæontographical Society of a monograph on the British Fossil Eocene Flora, to give in the GEOLOGICAL MAGAZINE a brief analysis of their theories.

In the first paper under consideration Baron von Ettingshausen states that the present vegetation is but a phase in the development of plants, and has resulted from earlier and preparative conditions. By careful study of living plants, we may trace their genetic connexion with those of Tertiary times, and even with still more ancient Floras. But in this research, at present, the most important of Fossil Floras are those of the Tertiary Period, on account of their greater resemblance to existing forms.

In this period the types of actual living plants were in existence, although not then characterizing distinct phyto-regions, as we now see them, but all growing in close proximity. As examples of this we find, in the same beds of the Tertiary formation, remains of European plants such as oak and pine mingled with palms and other tropical plants and with extra-European Sequoias, Cinnamons, Dryandras, etc. Having worked out an explanation of this strange mingling on the supposition that these were assemblages of plants brought together which had grown at different elevations, Ettingshausen was led to abandon that theory by a visit to the fossils *in sitû* at Steiermark, and became at once convinced that the *Coniferæ*, *Betulaceæ* and *Cupuliferæ* had not lived in zones above the Palms and *Musaceæ*, but that the otherwise enigmatical association of these plants is easily explained by supposing that the predecessors of our European species, which differ from their descendants in many respects, were able to exist in a warmer climate.

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[1] I have preserved the original term Flora-element, although it is unfortunately open to more interpretations than the sense in which it is here used.

In comparing the Tertiary Flora with that now living, Ettingshausen considers the former as a collective stock-flora, which may be analysed into its component Flora-elements. By *Flora-elements* he means all those ancient plant-forms whose representatives at present belong exclusively to, and characterize some natural floral region.

The genetic relationship of some of the forest trees of the American Continent, for example, to Tertiary trees can be traced directly from horizon to horizon, as in the case of *Castanea atavia* to *C. vesca.* In the development of our European Flora the analogues of trees now living in America have played the most important parts. In the Tertiary times the vegetation of the whole earth is supposed by Ettingshausen to have had one and the same character, distinguished by the general mixture of what he terms all the Flora-elements—as far at all events as climatic conditions allowed,—which contained within itself the elements from which all existing Floras are derived.[1]

He characterizes these Flora-elements as chief-elements,[2] and collateral-elements.[3] For example, the Mid-European Flora-element in the Tertiaries stands in reference to the existing Flora of Europe as chief-element; whilst all the exotic forms contained in the same beds stand in the relationship of collateral-elements. We frequently see certain plants taking their place in the natural Flora of a region which appear extraneous to the general character of that Flora, sometimes even so abundantly represented as to influence the character of the Flora. These are descendants of collateral-elements.

Reference is then made to the Flora of Japan, which presents a mixed assemblage of tree-forms, recalling forcibly the Flora of our Tertiaries. In that place are to be seen growing side by side apparent representatives of the vegetation of the East Indies and the Amazons, of Europe and North America.

The same mingling of types is seen, though less markedly, in the woods of North America. The Southern States possess endemic and European, Japanese and sub-tropical forms. In neither case could this be the result of immigration.

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[1] The Flora of America, it may be remarked, is now known to have been at least as distinct from that of Europe in Cretaceous (?) times as at present.—J. S. G.

[2] Haupt-element. [3] Neben-element.

Glancing at the distinctive Flora of the Californian coast-line, we see a series of European genera (although represented by other species), whose origin Ettingshausen states to have been derived, in Tertiary times, from European elements, which elements, being universally distributed, were, however, according to the Baron's theory, also present even at that time in California. As instances, he traces the Californian *Quercus Douglasii* and *Q. agrifolia* to their supposed ancestor. The greater the resemblance between different species, the greater the probability that they are derived from a common stock; as, for example, we see that *Liquidambar styraciflum* and *L. orientale* are both derived from the Tertiary *L. europæum*, whilst two other species, closely resembling each other, *L. altingia* and *L. chinense*, were derived from another and still unknown ancestor.

In the phyto-regions of Japan, North America, the Mediterranean, etc., alongside of the chief-elements the collateral-elements have also contributed their share to the character of the vegetation; whilst in the temperate regions of the Himalayas and Andes they have markedly influenced it. On the other hand, the Cape and Australian Floras owe their pronounced character to a remarkably preponderating development of the chief-elements, although, even here, residua of the collateral-elements are to be traced. As the Cape and Australian Flora-elements are, upon this theory, derived, not simply from the European, but the universal Tertiary Flora of the temperate regions of the world, they had originally the same composition. At the Cape, plants of an Australian, and in Australia those of a South African character grow. This theory explains the community in the recent Floras of both regions of a number of families and genera, of which the *Proteaceæ*, *Ericaceæ*, and half a dozen others, are conspicuous examples. In other natural Floras of the world remains of these elements are also met with as representative genera and species. Thus in the Mediterranean region the Cape-element is seen in the *Ericas*, species of *Mesembryanthemum*, and a *Pelargonium* and *Apteranthes* (representing Cape *Stapeliæ*). *Callitris*, belonging to the same Flora, is descended from an Australian element. The numerous representatives of the existing Australian-element in the Tertiary Flora of Europe do not indicate that these belong to an older type of vegetation, but simply show the former connexion of these Floras through the Flora-elements, when distant parts of the globe were yet united.

The Baron then explains that in some regions the Tertiary Flora-elements have come down almost unchanged, and in others have taken special characters, arising from the almost exclusive development of some only of the Flora-elements, and the expulsion or suppression of the rest. Besides the Tertiary Floras, beds of Cretaceous age have furnished plant-remains. We can trace some of the Flora elements to this period, and prove that in it even simpler elements are contained, which unite in themselves some of the parent-stocks, which we have been considering as Tertiary Flora-elements.

The differentiation of the Flora-elements, commenced, according to Ettingshausen, in the Cretaceous epoch, progressed continually throughout the Tertiaries, during which period was prepared the way for later and still greater divisions. With the dawn of the post-Tertiary, this differentiation was for the most part accomplished, and in Europe the tropical and Australian forms had been gradually pushed out by those of our temperate zone. So says Ettingshausen. We cannot do better than conclude this notice by translating almost verbatim the inferences which he draws at the conclusion of his paper from the facts we have been considering. They are as follows:

1. All the present natural Floras of the earth are connected together through the elements of the Tertiary Flora.
2. The character of a natural Flora is determined by the more pronounced development of some of the Flora-elements (the chief-elements).
3. In the construction of the recent Floras the collateral-elements have shared, as far as climatal conditions permitted. A mixture of plants has resulted, possessing characters foreign to the general Flora, sometimes present only in subordinate numbers, but sometimes in such rich masses that they appear distinctly characteristic.
4. The representative species in the present phyto-regions are members, mutually corresponding one with another, of the same or similar Flora-elements.

NOTICES OF MEMOIRS.

I.—The Insect-Fauna of the Tertiary Period.

AT a meeting of the Brighton and Sussex Natural History Society, held on March 8th, at the Brighton Free Library and Museum, Mr. H. Goss, F.L.S., F.Z.S., etc., communicated a paper on "The Insect Fauna of the Tertiary Period, and the British and Foreign formations in which Insect-remains have been detected." Mr. Goss remarked on the neglect of Fossil Entomology in this country, and called attention to the importance of an acquaintance with fossil insects, and the valuable conclusions which might be arrived at from their study, bearing upon the geological conditions of the earth during the respective periods of its existence. He also observed that the researches of Professor Heer had taught us that the study of insect-remains, and a comparison of the numerical proportion existing between the *Carnivorous* and *Herbivorous* species of any period with that existing at the present day, would afford a valuable clue to the state of the vegetation and climate prevailing in former periods.

After quoting Sir Charles Lyell as to the importance of an acquaintance with fossil insects, Mr. Goss reviewed the bibliography of the subject, beginning with Scheuchzer's "*Herbarium diluvianum*" (published in 1700). He called special attention to the importance of Professor Heer's great work "Die Insekten Fauna der Tertiärgebilde von Œningen und von Radoboj in Croatien;" and to the very valuable memoirs recently published by M. Oustalet, Mr. S. H. Scudder, and others. He also drew attention to the fact that the Rev. P. B. Brodie had published a book[1] on this subject so long back as 1845.

Mr. Goss then made some observations as to the nature of the strata in which insect-remains were most commonly detected, and offered some explanation of the reasons why fossil insects were frequently met with in marine formations. He then reviewed in descending order the principal deposits of the Tertiary period in which insect-remains had been detected in Great Britain, on the Continent, and in America.

After alluding to the remains of a few insects from Post-Tertiary strata, including *Coleoptera* from the Post-Glacial Drift near Colchester, and the Forest bed and lacustrine deposits in the cliffs along the Norfolk coast, and from the lignites of Uznach in Switzerland, he proceeded to enumerate the orders of insects, and the numbers of each, detected in British and Foreign Tertiary strata. With the exception of a few *Coleoptera* from the Lower Miocene of Antrim, Ireland, and from the Middle and Lower Eocene of the Isle of Wight, no well-authenticated remains appeared to have been found in English strata of this period. On the Continent they appeared to have been found in more or less abundance at Œningen in Switzerland, Radoboj in Croatia, Corent and Menat in Auvergne, Siebengeberge on the Rhine, Aix in Provence, and Monte Bolca in Upper Italy.

The author quoted Sir C. Lyell's description of the Œningen strata belonging to the Upper Miocene period. From these strata Prof. Heer obtained 5081 specimens, comprising 844 species, viz:—*Coleoptera*, 518 species; *Neuropetera*, 27; *Hymenoptera*, 80; *Diptera*, 63; *Hemiptera*, 133; *Orthoptera*, 20; *Lepidoptera*, 3.

Mr. Goss alluded to the large proportion of Herbivorous *Coleoptera* amongst the Œningen fossils, and remarked that as they were always more abundant as the Equator was approached, it might be inferred that the climate of Œningen was at the period somewhat more tropical than at the present day, and this was, he said, the opinion of Dr. Heer and M. Oustalet. Allusion was then made to the present geographical distribution of the Œningen species.

From the Middle Miocene formation of Radoboj about 312 species had been detected. In these strata the *Hymenoptera* were the best represented. The Butterflies were represented by three species, one of which belongs to an extinct genus.

According to the researches of Bronn, Germar, Giebel, Dr. Heer, Dr. Hagen, and Herren C. von Heyden and L. von Heyden, the lignites of Rott in Siebengeberge near Bonn, belonging to the Lower Miocene, have produced about 90 species. From other deposits of Brown Coal about 125 species had been described by Dr. Hagen, C. von Heyden and others.

Mr. Goss drew attention to the remarkable formation known as

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[1] "On the Fossil Insects of the Secondary Rocks," containing many interesting determinations of fossil insect-remains, by the Rev. P. B. Brodie, and Prof. J. O. *Westwood, of Oxford.*

"Indusial Limestone" and to other strata of the Auvergne, Central France. From these strata M. Oustalet had described some 49 species, 30 of which were referable to the order *Diptera*.

Reference was then made to the formations of Aix, in Provence, belonging to the Upper Eocene period, from which more fossil insects had been obtained than from any other deposits except Œningen.

One noticeable fact about these strata was that out of the nine Butterflies detected in the European Tertiaries, 5 of them had been found here.

The marls and limestones of Monte Bolca belonging to the Middle Eocene period were next referred to; seven species of insects have been described from them by Signor Massalongo.

The American strata of the Tertiary period in which fossil insects had been discovered were then noticed. It appeared from a paper of Mr. Scudder's that Mr. Richardson had discovered about 40 species of insects in these strata; besides these, about 31 species of *Coleoptera* have been described by Mr. S. H. Scudder of Boston, U.S.A.

In conclusion, fossil resin, or amber, from the Baltic, was described, and a list of the genera of the various orders of insects discovered therein was given, and allusion was made to the various writers who had treated of amber and its organic remains.

II.—ON SOME FUSULINA LIMESTONES. By DR. G. STACHE.

Imper. Geol. Instit. Vienna, Meeting December 19, 1876.

[Communicated by Count MARSCHALL, F.C.G.S., etc.]

A. *From Upper Carniola.*

NEW localities of Fusulina-rock in this district are—1. The Leptlin ravine, near Fauerburg; in the Carboniferous area of black and grey limestones and calcareous breccias. 2. Assling; white dolomitic limestones. 3. Neumarkt; dark-red calcareous breccias. 4. The Gerauth Valley, near Neumarkt; black limestones. 5. The same locality; white and light-grey limestones. 6. Brown sandy marls.

The black limestones of the first of these localities are particularly rich in large spherical forms, some of them agreeing with *Fusulina princeps*, Ehrenberg. sp. Other deposits contain a series of forms approaching externally the type of *F. cylindrica* or of *F. ventricosa*.

The facts at present known concerning the Fusulina-beds in the Southern Alps[1] lead to the following conclusions:—

1. The West to East extension of these beds in the Southern Alps is probably very considerable.

2. These strata differ much in petrographical type; they represent, however, a definite *facies* among the Carboniferous group, in some way analogous to that of the Alveolina-beds of the Istrio-Dalmatic Lower Miocenes.

3. These Fusulina-rocks appear at various horizons both above and below the Upper Carboniferous series. They constitute, how-

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[1] See also notes by Prof. E. Suess, *Proceed. Imp. Geol. Inst.* Vienna, Jan. 4, 1870.

ever, a coherent group of beds, mainly belonging to the upper subdivision of the Carboniferous group, thus representing a sea-coast *facies*, nearly equivalent to the dry land *facies* of the Upper Carboniferous sub-division abounding in vegetable remains.

B. *From Borneo.*

The Fusulina-limestones of this island are represented by two varieties (probably from different horizons), differing both lithologically and palæontologically.

1. The prevalent variety is a somewhat siliceous limestone, unequally speckled with light-yellowish and reddish-grey colours, intersected by white and reddish veins and fissures, and abounding in large spherical *Fusulinæ.* These occur nearly complete, and somewhat silicified; or appear in various sections on the surfaces altered by decomposition. The prevalent form, with numerous whorls of the spiral, is essentially different from the form figured by Mr. Brady[1] as *Fusulina princeps*, Ehrenb. sp., showing (like the large spherical forms from Carinthia and Carniola) only six whorls. The new species, externally similar to the four-whorled Carinthian *F. Hoeferi*, St., is *F. Verbeeki*, Geinitz, characterized by the presence of from ten to twelve whorls.

Some sections are referable to *Alveolina*, or to a genus nearly allied; being types of a new species, *Alveolina* (?) *atavina.*

2. The second variety of Fusulina-rock is a variegated and generally fine-grained breccia, including some spherical forms, and very many sections of more abundant, smaller, cylindrical, thick-fusiform or oblong-oval individuals, varying in dimensions. According to the position of analogous calcareous breccias in the Southern Alps, these Bornean breccias may belong to an horizon immediately above that of the first variety.

C. *From the Isle of Chios.*

According to Mr. Teller, the Fusulina-limestones here appear so widely spread in the form of blocks and smaller fragments, that they may be supposed to be a rather important constituent in the geological structure of this island. These limestones are grey, and include an abundance of broken stems of Crinoids, together with rather frequent, large, and elongated *Fusulinæ*, standing next to the Carinthian *F. Suessi*, St., and to the American *F. elongata*, Shum. Certain reddish and yellow portions of the limestone, rather sandy and argillaceous, exhibit on their decomposed surfaces several smaller forms of Foraminifera.

III.—On the Jurassic Formations of Russia. By Dr. Neumayr.

From the Reports Imperial Geological Institute Vienna, October, 1876.

[Communicated by Count Marschall, F.C.G.S.]

A SEAM of earthy brownish coal, with coniferous wood, resting on limestone, considered to be Devonian, is worked at Tchoulkowo, south of Moscow. The coal-seam is overlain by a bed of clay with pyritized Cephalopods characteristic of the lowermost Jurassics.

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[1] Geol. Mag. New Series, Vol. II. p. 537, Pl. XIII. Fig. 6.

The Upper Jurassic division is represented by light-coloured glauconitic limestones, containing Cephalopods, Gasteropods, and Brachiopods. Dr. Neumayr found the following fossils in the clay:—*Harpoceras Brighti*, Pratt; *H. lunula*, Ziet.; *Perisphinctes scopinensis*, sp. nov.; *P. Mosquensis*, Fischer (a characteristic Russian form); *Stephanoceras coronatum*, Brug.; *Cosmoceras Jason*, Ziet.; and *C. Pollux*, Rein.; all in a state of preservation closely resembling that of the fossils in the Ornatus-clays of Swabia. Of the above-named seven forms, five are commonly met with in the Middle and Upper Callovian of W. Europe, the zones of *Simoceras anceps*, and of *Perisphinctes athleta*; they must be considered as *Immigrants;* and even the two others may be modified descendants (?) of *Perisphinctes curvicosta*, a form widely spread over Central Europe.

The Fauna of Tchoulkowo is exceptional among the Jurassic Faunæ of Russia, both by its antiquity and by its striking analogy to those of Western Europe. The Fauna from the red and yellow Sandstones of Jelatma on the Oka is next related to it.

The Russian Jurassic formations, in descending order, are:—

a. Inoceramus-bed of Simbirsk.

b. Olive-green glauconitic sandstones, with *Amaltheus catenulatus*, Fisch., and *Perisphinctes fulgens*, Trauts.

c. Aucella-bed, with *Amalth. catenulatus*, Fisch., and *Aucella Mosquensis.* (Upper Moscow bed.)

d. Beds with *Perisphinctes virgatus*, von Buch. (Mid. Moscow beds.)

e. Beds with *Amaltheus alternans*, von Buch. (Lower Moscow beds.)

f. Strata of Tchoulkowo and Jelatma, with *Cosmoceras Jason*, Ziet., and *Stephanoceras coronatum*, Brug.

g. *Belemnite*-shales of Jelatma; besides several merely local deposits.

According to Dr. Trautschold, the division *e* answers to the deposits between the lowest "Bathonian" and the uppermost "Oxfordian;" division *d* being the "Kimmeridgian;" and division *e* the "Portlandian."

Dr. Neumayr is of opinion that only ten species of West-European Cephalopods, all characteristic of the Middle and Upper "Callovian" and of the Upper and Middle "Oxfordian," are met with in the Russian Jurassics, among which only the deposits of Tchoulkowo and Galiowa can be paralleled with those of Western Europe. The Fauna of the clays of Tchoulkowo and the equivalent deposits of Jelatma answer exactly to that of the Upper and Middle "Callovian," including a number of forms identical with those of Western Europe. The horizon of Galiowa (division *c*) yields forms referable to the zones of *Aspidoceras perarmatum* and *Peltoceras transversarium*, together with some specially Russian species. Some forms of division *d* may be considered to be representative types of Western forms, such as *Perisphinctes virgatus*, *P. polyplocus*, *P. Pallasianus*, d'Orb., and *P. Witteanus*, Oppel.

The divisions *a*, *b*, and *c* may be considered as equivalent to the Uppermost Jurassics; possibly division *a* may be even ranked among the Cretaceous series. The concordance with West-European forms, so conspicuous in the lower horizons, gradually diminishes upwards. The "autochthonic" forms of the Moscow Jurassic fauna, that is, those originated within the Centro-Russian Basin by transformation (?) of immigrated Western-European forms, are associated with the transformed (?) offspring of Indian immigrants (as some *Perisphinctes*, standing next to *P. frequens*, Oppel, a Tibetan form); and, in division *c*, with those from a third (northern) origin, such as *Amaltheus catenulatus.*

From all these facts, Dr. Neumayr endeavours to trace five distinct phases in the formation of the Russian Jurassics:—

1. Crimeo-Caucasian phase. Previously to the deposit of the "Kelloway" beds the Russian Basin is invaded by the sea, and Belemnitic shales, analogous to those of the Crimea and the Caucasus, are deposited.
2. Free communication with the Centro-European sea existing during the "Middle Callovian" Period, immigration and exclusive prevalence of a Fauna of unmixed Centro-European type obtain.
3. Continued immigration of Western forms; and immigration of others from the newly opened Indian Sea, in the beginning of the "Oxfordian" Period; with transformation (?) of the immigrants into autochthonic forms.
4. Connexion with the Western Sea closed; development of a special Russian Fauna in the *Perisphinctes virgatus* beds; Centro-European forms only represented by analogous species.
5. Great Northern transgression, coeval with the deposition of the *Aucella* beds; communication with the Northern Sea (probably already existing) notably enlarged; immigration of *Aucella, Amaltheus catenulatus*, and other extraneous types.

Dr. Neumayr described two new species: *Perisphinctes scopinensi* from the Ornatus-clays, and *Waldheimia Trautscholdi* from the glauconitic limestones of Tchoulkowo.

IV.—Remains of Man and Pleistocene Animals in the Loess o the Danube. (From the Vienna Imperial Acad. Sciences Meeting February 1, 1877.)

THE Danube, during the Diluvial (Pleistocene) Period, covered all the northern portion of the Vienna Basin; and left, on it retreat to its present channel, a thick deposit of laminated loam (Loess), overlying the Tertiaries. Near Zeiselberg, at the mouth o the Kamp Valley, Count Wurmbrand discovered in 1876, beneath unmoved layers of Loess, a rich deposit of bones, and under tha a blackish stratum abounding with fragments of charcoal an with flints bearing traces of human workmanship. Other deposit also with bones and worked flints exist in the neighbourhood The bones in the Loess here are those of Diluvial (Pleistocene animals, namely, Mammoth, Rhinoceros, Reindeer, Horse, Ox Wolf, and Bear. The local conditions contradict the supposition tha these remains were carried to their present position from a distanc by currents of water or other agency. The excavations are still goin on, partly at the expense of the Vienna Academy. Count M.

V.—FOSSILS FROM THE COAL-MEASURES OF BOHEMIA. By D. STUR and A. FRITSCH. Imp. Geol. Inst. Vienna, Meeting Dec. 5, 1876.

[Communicated by COUNT MARSCHALL, F.C.G.S.]

1. Three species of fossil Plants were lately found for the first time between the first and second Coal-seams of the Kladno-Schlan Basin, namely, *Sphenopteris irregularis*, St. (together with *Asterocarpus Wolfi*, Stur, in the same state of preservation as in the roof of the upper Coal-bed of Radnitz); *Alethopteris Serlii*, Brongn. (only the apex of a frond); and *Pecopteris elegans*, Germ. (a large fragment of a frond, agreeing in minute details with a specimen from Wettin in Saxony).

2. Animal-remains have only been met with in one subdivision (Radnitz Beds) of the Centro-Bohemian Carboniferous Formation. They all belong to essentially Terrestrial Animals—*Crustaceans, Arachnids*, and *Insects*; and are distributed thus:—

In the roof of the upper Radnitz Coal: *Lepidoderma Imhofi*, Reuss; *Xylorycles planus* (borings).

In the upper Radnitz Coal-seam: *Gampsonyx*, sp. (in laminated coal).

In the roof of the lower Radnitz Coal: *Palaranea borassifoliæ*, Fr.; *Cyclophthalmus senior* (*Microlabis Sternbergi*), Corda; *Xylorycles septarius* (borings).

In the floor of the Radnitz Beds: *Gampsonychus parallelus*, Fr.; *Acridites priscus*, Andrée.

Excellent specimens of all these forms are preserved in the newly established Geological Museum of Prague.

VI.—THE DISTRIBUTION OF THE CEPHALOPODA IN THE UPPER CHALK OF NORTH GERMANY. [VERBREITUNG DER CEPHALOPODEN IN DER OBEREN KREIDE NORD-DEUTSCHLANDS, VON CLEMENS SCHLÜTER.] (Zeitschrift der Deutschen geologischen Gesellschaft, Band xxviii. heft 3.)

THIS Memoir by Herrn Clemens Schlüter constitutes a kind of supplement to his work "Cephalopoden der oberen deutschen Kreide."

The Upper Cretaceous beds of North Germany are subdivided into the following zones in ascending order, viz.:—

Zone of *Pecten asper*.
" *Amm. varians*.
" *Amm. Rhothomagensis*.
" *Actinocamax plenus*.
" *Inoceramus labiatus*.
" *Inoceramus Brongniarti*.
" *Heteroceras Reussianum*.

Zone of *Inoceramus Cuvieri*.
" *Amm. Margæ*.
" *Scaphites binodosus*.
" *Becksia Soekelandi*.
" *Amm. Cœsfeldiensis*.
" *Heteroceras polyplocum*.

A brief sketch of the geographical extent, and equivalents in France or England when such exist, together with a list of the Cephalopoda obtained, is given under each of these headings; whilst appended will be found a table showing the respective vertical ranges of the 155 species of Cephalopods in the Chalk of North Germany; or, rather, their respective positions in the vertical series: for the most prominent fact revealed in this table is the limitation of these several species to the different horizons, only a few being common to two or sometimes three consecutive zones. B.B.W.

REVIEWS.

I.—ON THE LOESS OF THE RHINE AND DANUBE. By THOS. BELT, F.G.S. (Quarterly Journal of Science, January, 1877.)

THE Loess in the valleys of the Rhine and Danube has formed the theme of many papers published both here and on the Continent, and numerous theories have been advanced respecting its origin; but probably no bolder hypothesis has been put forward than that now propounded by Mr. Belt.

The paper commences with a description of the character and extent of this deposit, the position it occupies with respect to the rivers and slopes of the valleys being illustrated by woodcuts (in which the vertical scale is of course greatly exaggerated). The greatest elevation to which it attains in the valley of the Rhine is 800 feet above the sea-level, whilst in the basin of the Danube it has been found at a height of 1300 feet above the sea.

Mr. Belt thinks that he has been able to trace the gradual passage of the Loess into the northern drift; and the animal-remains that are found in it being of the Glacial type (see ante, p. 168), he is led to class the Loess as the southern equivalent of the northern drift (the Upper Boulder-clay of Searles V. Wood).

Respecting the origin of this wide-spread alluvium, the author shows in the first place that it must have been deposited subsequent to the excavation of the valley system, and not during the course of its formation; and he complains that "the usual explanation of the facts of the Glacial period is one continued appeal to the hypothesis of great oscillations of the earth's surface at that time." "But is there," he asks, "really no other way of getting water up to the heights we require without resorting to this extreme hypothesis?" This "other," and simpler, way is to be found in the theory already advanced by Mr. Belt on a former occasion when treating of the deposition of the Northern drift, viz. "That the ice of the Glacial period flowed principally down the ocean depressions, and blocked up the drainage of the continents as far as it extended, causing immense lakes of fresh or brackish water." Mr. Belt then explains how, according to his hypothesis, a glacier of fresh-water ice occupied the basin of the Atlantic, and reared its snowy crest some 1700ft. above the now sea-level, damming back the drainage of Europe, and converting the lowlands into a lake studded with icebergs. This huge lake "was once completely drained; at first gradually, but from about 500ft. above the present level of the sea suddenly and tumultuously by the breaking away of the icy barrier, and thus was produced a great deluge or débâcle that swept over the lowlands, and covered them with a mantle of false-bedded sands and gravel. . . . . After being thus broken, the icy barrier soon closed up again, and the great lake was reformed, and this time was much more permanent."

Such is the picture of the Physical Geography of the period given us by Mr. Belt; but whether the land to the south is sufficiently high and continuous to maintain the waters of an immense lake at such an elevation as 1700ft. above the modern sea-level, or whether the presence of such an enormous body of ice would not be likely to freeze up the rivers altogether, Mr. Belt does not tell us.

B. B. W.

II.—PROFESSOR L. G. DE KONINCK ON THE PALÆOZOIC FOSSILS OF NEW SOUTH WALES, ["RECHERCHES SUR LES FOSSILES PALÉOZOÏQUES DE LA NOUVELLE-GALLES DU SUD (AUSTRALIE)."] Reprinted from the *Mémoires de la Société Royale des Sciences de Liège*, 2ème série, t. vi. (1876), 140 pp. 8vo. and 4 quarto plates.

IN this important Memoir Professor de Koninck describes all the Silurian and Devonian species which have been collected by the Rev. W. B. Clarke, F.R.S., in New South Wales during thirty years of scientific labours in the colony. The following paragraph of the Introduction hints somewhat obscurely at the reasons which induced Mr. Clarke to send his fossils so far to be named, and perhaps demands fuller explanation. Prof. de Koninck says:

"Mr. Clarke, in communicating to me the Palæozoic fossils gathered by his care in New South Wales, wished to check his own observations and to confirm their accuracy in a manner which he has not dreaded to seek five thousand leagues from the country explored by him, when, with inconceivable want of judgment [*aberration d'esprit*], certain geologists disdained to make use of them, although ready at hand, in arriving more surely and quickly at the methodical classification of the formations the study of which was confided to them." (p. 6.)

Whatever may be alluded to in these words, it is clear that no one could have set about the work of determining the species represented in Mr. Clarke's collection with more zeal or learning than the great Belgian palæontologist.

Fifty-nine Silurian species are enumerated and described. Of these, twenty-seven are referred to the Ludlow horizon, and the remaining thirty-two to the Upper Llandovery, the greater number of the former consisting of Corals and Crustacea, and the latter almost exclusively of Mollusca and Crustacea. No Graptolites are recorded from New South Wales, although they are common in Victoria (=Bala Beds, according to Prof. McCoy and Mr. Etheridge, jun.).

Thirteen species are described as new, but here, as in the case of most of the thirty new Devonian forms described, they all belong to European or American genera, of which closely-allied species are known.

The Upper Silurian Fauna here described therefore is strictly analogous to those of Europe and America, and is not even sensibly distinguished from them by such minor characters as size or other individual peculiarities of local value. Moreover, the beds which contain the Upper Llandovery fossils are chiefly argillaceous, whilst the overlying Ludlovian forms occur in hard reddish quartzites and in white or greyish limestone.

The Devonian species described are eighty-one in number, of [illegible] five are considered as Upper Devonian. These are: [illegible] *ductoïdes*, Murch.; *Chonetes coronata*, Conr.; *Rhyn*-[illegible], Phill.; *Spirifer disjunctus*, Sow.; and *Aviculo*-[illegible] de Kon.

[illegible] again we find that, with four exceptions only, every one of [illegible] New South Wales Devonian fossils belong or are closely allied [illegible] or American species of the same age. The exceptions [illegible] described by Prof. de Koninck under the following names: [illegible] (?) *Clarkei*, *Billingsia alveolaris* (this genus is transi-[illegible] between *Aulopora* and *Syringopora*), *Niso* (?) *Darwinii* (this [illegible] first record of a representative of this genus from rocks older [illegible] Tertiary), *Mitchellia striatula* (a Buccinid shell somewhat [illegible] to *Columbella* and represented by one specimen only).

The Carboniferous species are not included in the present memoir, [illegible] the writer states that their enumeration will carry out the law which he has shown holds with regard to Devonian and Silurian faunas. The South Wales Carboniferous Fauna will not be found to differ in any marked degree from those of America and Europe. This is but a confirmation of what we had been led to expect from the work of identification begun by Mr. W. B. Clarke himself. Prof. McCoy, Messrs. Selwyn, Salter, and R. Etheridge; but it is impossible to overrate the interest of the subject both to geologists and to biologists.

G. A. L.

III.—THE GEOLOGY OF THE EASTERN END OF ESSEX. By WILLIAM WHITAKER, B.A., F.G.S. [Explanation of Quarter Sheet 48 S.E. (with the adjoining part of 48 N.E.) of the Geological Survey Map of England and Wales.] 8vo. pp. 32. (London, 1876. Price 9*d*.)

THE area described in this concise little memoir, embracing about 50 square miles, includes the country around Walton Naze and Harwich, and forms part of the London Basin.

It boasts no very striking or picturesque scenery, being, as Mr. Whitaker describes it, "essentially a clay-country, with gentle slopes, nowhere probably reaching to a greater height than 150 feet above the sea, the higher ground being for the most part flat, from the cappings of gravel, the remains of a once continuous plateau. The slopes mostly sink into alluvial flats, which are to a great extent below the level of high water, and are protected only by artificial embankments." The geology, however, furnishes many points of considerable interest, such as the Cement-stone beds of Harwich and the Red Crag of Walton Naze, while the evidence furnished by the deep well at the former locality has more than a local importance, proving, as it did, the occurrence of Palæozoic rocks at a depth of 1029 feet beneath the surface.

The formations described include: (1) the London Clay; (2) the Red Crag of Walton Naze and Beaumont, with the description of some small outliers first noticed during the mapping of the country, and a notice of the Red Crag of Harwich described by Dale in 1732, and which is now entirely destroyed by the encroachment of the sea; (4) drifts, including gravel, sand, and loam, some probably of Glacial age, while other deposits are classed as Post-Glacial, together with recent deposits of alluvium, blown sand, and shingle.

The appendix contains records of all the well-sections; and lists of fossils from the London Clay of Harwich; and from the Red Crag of Walton Naze and Beaumont; and from the Pliocene (probably Post-Glacial) deposits of Walton and Harwich.

References are given to the works of the chief observers, amongst whom may be mentioned Dale, the Rev. W. B. Clarke, Dr. J. Mitchell, Mr. John Brown, Prof. Prestwich, and Mr. S. V. Wood, jun.

H. B. W.

IV.—ON NEW AND LITTLE-KNOWN FOSSIL FISHES FROM THE EDINBURGH DISTRICT, No. I. By R. H. TRAQUAIR, M.D., F.G.S. (Proceedings Royal Society of Edinburgh, Session 1876–77.)

IN the above memoir Prof. Traquair has given lengthy and minute descriptions of three species of Fossil Fishes from the Blackband Ironstone of Venturefair Colliery, Gilmerton, and the Carboniferous shales of Wardie. They are referred to two genera, *Nematoptychius*, Traq., and *Gonatodus*, Traq., and to the family *Palæoniscidæ*. The first "genus was instituted by the author for the reception of the *Pygopterus Greenockii* of Agassiz, and characterized in the 'Annals and Magazine of Natural History,' for April, 1875." He here describes another species, *N. gracilis*, Traq., founded upon two specimens, the only ones at present known, and which are respectively nine inches, and about ten inches in length, the form is elongate and slender, the dorsal fin being situated very far back, and the scales small, but their configuration is apparently the same as in *Nematoptychius Greenockii*," the external ornamentation being the same as in that species. "The external surface of the lower jaw is ornamented with a minute and very close tuberculation; the dental margin of the maxilla is also tuberculated, but the rest of its surface is marked with delicate ridges." "Large conical teeth occur in both jaws, with a few of the external series of smaller ones." The paired fins may be termed small, the pectoral and ventral in one specimen being respectively 1 inch and ¾ of an inch in length; the rays are fine, but their number not accurately known. He remarks "that the present species is closely allied to the powerful *Nematoptychius Greenockii*, Ag. sp.—it differs, however, from the latter in several particulars, beside its smaller size."

Gonatodus is a new genus, and comprises two species; it is founded in part for the reception of a specimen—one of three—from the Carboniferous shales of Wardie, and described and figured by Agassiz as *Amblypterus punctatus*. These three imperfect specimens, our author states, having personally examined and compared them "with a series of entire fishes from the Wardie beds, establish the fact, that the *Amblypterus punctatus* of Agassiz was founded upon fragments of two distinct species, the specimen with the head, but without the hinder part of the body, being even generically distinct from the other two." And that "the peculiar form and arrangement of the teeth in the first of these render necessary the institution of a new genus, to which I have given the name of *Gonatodus*." He, however, preserves Agassiz's name of *punctatus* for the species; but redescribing it from original and careful observation of the more complete material at his command. He further observes that "the peculiar dentition of *Gonatodus* was, however, first correctly described by Mr. R. Walker, in a fish from the oil shales of Pitcorthie, Fifeshire, to which he gave the name of *Amblypterus anconoæchmodus*." And that "Mr. Walker's fish undoubtedly belongs to the same genus, and may possibly be the same with *G. punctatus*."

Gonatodus macrolepis, Traq., is a new species, ranging in length from four to seven inches, and occurs in the Blackband Ironstone. The configuration of the bones of the head, as far as they can be defined (for in the specimens examined they are all more or less crushed and broken), and their sculpturing, and also the configuration of the teeth are essentially the same as in the preceding species; but the scales on the anterior portion of the body are considerably larger than in *G. punctatus*, and as in that species the surfaces are brilliantly polished, and devoid of ornamentation, and their posterior margins are finely denticulated.

Ample and clear as are the descriptions, we cannot conclude without expressing regret that they have not been supplemented by good figures of the specimens upon which the species have been founded.

W. D.

V.—Mémoire sur les Caractères Minéralogiques et Stratigraphiques des Roches dites Plutoniennes de la Belgique et de l'Ardenne Française. By Professors C. de la Vallée Poussin and A. Renard. 4to. pp. 264, and 7 plates. (Brussels, 1876.)

DE SAUSSURE declared that mountains were not to be studied with the microscope. What would that venerable father of geology think could he see the "slicing" of rocks which is now going on all over Europe! It was the custom, not so very long ago, for geologists to be content, for descriptive purposes, with a small stock of words wide and rather vague in meaning—of which "trap" is a worthy example—words which bound one to very little or nothing. A hand-lens to be used in the field was the only auxiliary thought of in determining the lithological characters of rocks. Now all is changed, the geologist trembles as he hazards a name for the specimen he collects, for he knows not how wrong he may be proved to be by that newly-arisen votary of science—the Micro-petrologist. The rock-nomenclature of his youth is gone, he knows nothing of, and finds it hard indeed to learn the meaning of "fluidal structure," "devitrification," "globulites," "belonites," or "margarites," and the result is that he, as a rule, gives up the attempt, and relies, for the determination of his rock-specimens, on the knowledge of those who have made micro-lithology their special study. In England the number of these specialists is small but increasing, headed as they are by one of the founders of the new science—H. Clifton Sorby, F.R.S. Only the other day a Geological Survey Memoir was issued, a chief feature of which is the delineation of the microscopic structure of some of the rocks of the Lake District, leading to important conclusions. In this case the field geologist and the microscopist were one and the same person, but this is the exception. It is in Germany that this line of inquiry has attracted the greatest attention. There the influence of such men as G. Rose, Tschermak, Zirkel, Kenngott, Vogelsang, Möhl, Boricky, von Lasaulx, and a host of others has been such that not only have manuals of micro-petrography been published and sold, but that special Chairs for the teaching of the subject have been established in most of the Universities. In France the impulse has been felt, although not so strongly, and is rapidly spreading under the influence of Delesse, Des Cloizeaux, and Michel-Lévy. Now we have to record a brilliant beginning on the part of Belgium in the handsome memoir the title of which heads this notice.

The authors, both Professors, one at the Catholic University of Louvain, and the other in the Jesuits' College in the same town, thoroughly deserve the gold medal with which their work has been rewarded by the Academy of Belgium, and the extremely beautiful coloured plates with which it has been liberally furnished by that body.

The subject worked out by them was not absolutely untouched. André Dumont had long ago described the physical relations of the so-called "Plutonic" rocks of the Ardennes and the Rhine, and d'Omalius d'Halloy has left valuable notes on some of them. Quite recently also Prof. Malaise published a paper "On some of the Porphyritic Rocks of Belgium," which cleared up many errors, and brought to light a number of new facts;[1] but, armed with the microscope and their German method, the Louvain Professors have by their prize-memoir marked an era in the progress of Belgian geology.

We say geology advisedly, for although their procedure is lithological and mineralogical, yet their most interesting results are strictly geological. Thus they show that the amphibolitic and porphyroidal rocks of French Ardenne are regularly interbedded with the Cambrian slates and quartzites amongst which they lie, and that they are not intrusive, as they were long considered to be, but are of truly sedimentary origin. They hazard the opinion that the crystallization of these rocks took place at the bottom of the sea, very soon after their deposition, and when the materials were still in a plastic state. In the same manner, the schistoid eurite of Enghiem, the quartzose eurite of Nivelles with ripple-marks, the porphyroidal rocks of Monstreux, Fauquez, Rebecq-Rognon, Pitet, and Steenkuyp, all of which were looked upon as igneous, are proved to be derivative deposits. The Lower Silurian arkoses of Brabant are shown to be, not strongly metamorphic, but formed of transported crystallized materials only. The so-called "Hypersthenite" of Hozémont and Grand-Pré is demonstrated to be a gabbro, but its relation to the other rocks is not known. On the other hand, the quartziferous porphyry of Spa is undoubtedly intrusive, and so are the quartzose Diorites of Quenast, Rebecq-Rognon, and Lessines.

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[1] See Bulletins Acad. royale de Belgique, 2ème sér. t. xxxviii.

As we have hinted at before, the nomenclature of crystalline rocks is becoming a matter of increasing anxiety to the geologist. The present authors are to be complimented on the simplicity of the system they have adopted. One example will suffice: under the term "diorite quartzeuse," they designate a rock on which the following names have at various times been bestowed, viz.:

Porphyrite, Zirkel. *Porphyritic diabase*, Naumann. *Quartzose porphyry*, Delesse. *Oligoclase porphyry*, Roth. *Chlorophyre*, Dumont.

Synonymy is an evil which geology will sooner or later have to deal with, both as regards lithological and stratigraphical nomenclature, and the sooner some broad rules are accepted by the majority of the leaders of the science, the better. At present, in examining geological maps, or in reading geological works, half our time is wasted in finding out (if we *do* find out) what is meant by the terms used. Zoologists and Botanists are fortunate in having some generally-recognized laws of priority, tempered to some extent by fitness, and it certainly does not appear why Geology should continue to lack any relief of a more or less similar character.—G. A. L.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—February 7th, 1877.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.—

and 0·77 per cent. of silica. The altered rocks contain an abundance of quartz granules, due probably to the crystallization of progressively dissociated silica, as the specimens of rock in which these granules occur do not contain a larger proportion of silica than those in which its presence can hardly be detected under the microscope. The proportion of alkalies in the different specimens does not materially vary.

Overlying the second quarry at the east end of the mountain is an ash bed of reddish-brown colour, containing more than 10 per cent. of protoxide of manganese and nearly 20 per cent. of peroxide of iron, and showing a great diminution in the per-centage of silica when compared with the associated crystalline rock.

The author further described the characters of the uralite-porphyry of the Mawddach valley near Dolgelly, which is of a greyish-green colour, spotted with black, and consists of a granular base inclosing patches and crystals of uralite, the outlines of which are sometimes sharp and well defined, but generally rounded and merging into the general base.

2. "On new species of *Belemnites* and *Salenia* from the Middle Tertiaries of South Australia." By Ralph Tate, Esq., F.G.S., Professor of Natural Science in the University of Adelaide.

The author noticed the occurrence in deposits of supposed Miocene age in South Australia of a species of Belemnite (*Belemnites senescens*) and a *Salenia* (*S. tertiaria*). These fossils were obtained from Aldenga, twenty-six miles south of Adelaide, on the east coast of St. Vincent's Gulf, where the long series of sea-cliffs contains an assemblage of fossils identical with that of the Murray River beds. The *Salenia* is especially interesting on account of the discovery of a living species of the genus by the naturalists of the 'Challenger.'

3. "On *Mauisaurus Gardneri*, Seeley, an Elasmosaurian from the base of the Gault at Folkestone." By Harry Govier Seeley, Esq., F.L.S., F.G.S., Professor of Geography at King's College, London.

The author described the skeleton of a great long-necked Saurian obtained by Mr. J. S. Gardner from the Gault of the cliff at Folkestone. The remains obtained included a tooth, a long series of vertebræ, some ribs, bones of the pectoral arch, the femur, and some phalanges, indicating a very large species, which the author referred, with some doubt, to the genus *Mauisaurus* of Dr. Hector, founded upon a Saurian from the Cretaceous formation of New Zealand. He gave it the name of *Mauisaurus Gardneri*, in honour of its discoverer. A small heap of pebbles was found in the neighbourhood of the ribs, and it was supposed that these had been contained in the stomach of the animal.[1]

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[1] Mr. J. W. Hulke, with regard to the pebbles, suggested that the animal may not have swallowed them as an aid to the comminution of food in its stomach, but that they were introduced in the stomachs of fish which it had swallowed. The flesh and, subsequently, the bones of these would be digested and absorbed, whilst the indigestible stones, if the stomach of the *Plesiosaurus* was like that of Crocodiles, would be unable to pass through the small pyloric opening into the intestine, and must permanently remain in the stomach.

ANNUAL GENERAL MEETING.

II.—February 16th, 1877.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the *Library and Museum* Committee for the year 1876. The position of the Society was described as exceedingly satisfactory, and the income of the year was stated to have considerably exceeded the expenditure. The number of Fellows elected was fully up to the average. The Report further mentioned the bequest to the Society by the late Dr. H. C. Barlow of the sum of £500 Consols, the proceeds of which, under the title of the "Barlow-Jameson Fund," are directed by the testator to be applied every two or three years by the Council in such manner as may seem to them most conducive to the advancement of the science of Geology. It was also announced that Dr. Bigsby, F.R.S., F.G.S., had handed to the Council, in order that it might be awarded at the present meeting, a copy of the medal which he last year proposed to found, and that he further proposed to hand over to the Society the sum of £200 to be invested, the balance of the proceeds, after paying the cost of striking a medal, to be given biennially with the medal, as an aid and incentive to geological research.

In presenting the Wollaston Gold Medal to Mr. Robert Mallet, C.E., F.R.S., F.G.S., the President addressed him as follows:—

Mr. Mallet,—The Council of the Society has awarded you its principal Medal, which, originating with the illustrious Wollaston, has year by year received an increasing value by its reception by the most distinguished geologists in the world. This now famous prize is presented to you in recognition of the results of at least forty years of sedulous labour in some of the most important and difficult problems in Geology. Early in your career you commenced those studies relating to Earthquakes and Volcanos, which have occupied your time and taxed your energies down to the present date. From the first you took the correct logical method of investigation of phenomena, which were hardly disconnected from the supernatural; you collected the facts and indicated the manner in which you would employ them by your communications "On the Relation of Molecular Forces to Geology," and "On the Dynamics of Earthquakes, or an attempt to reduce their observed phenomena to the known laws of Wave-motion in Solids and Fluids." Moreover your reports "On the Experimental Determination of the limits of the transit-rate of the propagation of waves or pulses analogous to those of Earthquakes through solid materials," and on the results of your experiments on a cognate subject on the rocks of Holyhead, tended to prepare science for your theories of the Earthquake-wave, and for the establishment of that branch of knowledge which owes so much to you, namely Seismology. Your numerous reports to the British Association for the Advancement of Science upon Earthquakes, and your magnificent contribution to Science and Literature upon the Neapolitan Earthquake, added immensely to the knowledge of the subject; and your descriptions of the nature of the earth-movement, of the comparatively slight depth of the focus of motion, and of the nature and effects of the great marine wave, have been pregnant with results in geological theory. Of late years your able communication to the Royal Society "On Volcanic Energy" has been very prominently before the physicists and geologists of the Old and the New World. Full of admirably elaborated facts, it propounds a theory whose truth may be fairly estimated by the constant attention it has received. One of your earliest communications was "On the Trap-rocks of Galway," and your latest have been on the same subject. In your last essay you have endeavoured to solve the difficult question of the peculiar shape of basaltic prisms. In all these researches your employment of the exact sciences has been of necessity; and it is evident that the procedure has not only been most satisfactory in your argument, but that it has afforded a good example to those who cannot pretend to be geologists without an acquaintance with your works. You have followed out the line of research with which you commenced, and have done great service to geology, and also in directing the thoughts of scientific men towards the cosmical relations of the grandest phenomena of the globe, and the possibility of their explanation by thermo-dynamics. As a student of your works, and as a teacher of your views, I am proud of having this opportunity of conferring upon you this well-merited reward.

Mr. Mallet, in reply, said:—Mr. President,—I am deeply sensible of the great honour which has been conferred upon me by the award of this Wollaston Medal, the highest honour which it is in the power of the Society to bestow. I appreciate this honour as of the greater significance, since of all our scientific societies the Geological Society of London must be deemed that which in all respects is the most competent to form a judgment of those labours it has specifically named as justifying its decision in my own case. It is a somewhat trying ordeal, even to one of scientific achievement far beyond anything to which I can pretend, to bear his own work (as is usual on occasions such as the present) trumpeted forth from the Presidential chair before such an assemblage of eminent men, best capable of weighing their merits or demerits, as that I now see around me. I fear, Sir, that a good deal of the sunny colouring spread by you over whatever I may have been able to add to our knowledge of certain branches of Physical Geology, must become toned down to more sober tints, when, in future years, what I have been able to do shall be examined by the steady light of the study of the students and philosophers of a future age. It is given to no man so to interpret nature that his enunciation of her secrets shall remain for ever unmodified by the labours of his successors. Nor am I vain enough to imagine that the two subjects for which you have principally awarded me this medal can be exempt from that which is the common lot of all advances in science. What I have enunciated with respect to the laws of earthquake movements will fundamentally, I believe, admit of little of very radical change by the future advances of Physical Geology; for the laws I have assigned to seismic phenomena come so close to, and are such direct consequences of well-understood physical laws, as to be, like those laws, immutable; but in details future discovery cannot fail to alter something, and vastly to add to that I have been privileged to announce. For example, it was my own good fortune to ascertain, observationally and experimentally, the depth below the earth's surface whence the impulse came of the first earthquake ever submitted to measurement. That in the case of the great Neapolitan shock of 1857 proved to be only about eight or nine geographical miles; but it is highly probable that the depth of the centre of impulse of many great earthquakes may greatly exceed this, and may be found to bear some relation to the height of the greatest mountain-ranges adjacent. Thus my old friend, Dr. Oldham, after his examination of the region of the great Cachar earthquake a few years since in North-eastern India, found that its centre of impulse may have been thirty miles in depth from the surface. The views which I have enunciated as to the nature and origin of volcanic heat and energy, though I believe they will be ultimately found to be in the main a true interpretation of nature, must, I expect, be subject to large modification and addition in the future advances of knowledge. Our physical data in their numerical relations are still too defective to enable us to do much more at present than to sketch the general scheme of the laws of volcanic action, which must, by the way in which they fit into or explain many natural phenomena in widely diverse regions of nature, seem to afford credentials of their own reality in nature.

In making these remarks, I have, perhaps, already exceeded the limit that properly belongs to an occasion like the present; and, in conclusion, let me once more repeat my thanks for the kindness, sympathy, and appreciation with which you have to-day marked your approval of what little I may have been able to do for the advancement of our common object.

The President then presented the balance of the proceeds of the Wollaston Donation Fund to Mr. Robert Etheridge, jun., F.G.S., and addressed him as follows:—

Mr. Robert Etheridge,—I have great pleasure in handing to you the balance of the proceeds of the Wollaston Donation Fund, which the Society has awarded to you as a testimony of their appreciation of your industry and accuracy as a Palæontologist. You have laboured with great success amongst the fossiliferous rocks of Australia, and now you are advancing palæontological science by describing the rarer fossils of the invertebrate series from the Scottish Carboniferous formation. In offering you this distinction, I venture to hope that its reception will stimulate you to further inquiries into the Palæozoic faunas.

Mr. Etheridge replied:—Mr. President,—The recognition by the Council of the Geological Society of my labours, by the award of the Wollaston Fund, is both gratifying and complimentary to me. I have been and am still making great endeavours to elucidate some branches of our common science. For your award I beg to tender my sincere thanks. It will stimulate me to further exertions. The systematic study of the British Carboniferous Mollusca, to which I have more particularly confined my attention, has been for many years comparatively neglected, notwithstanding the vast amount of material gathered together through the energy and zeal of local scientific men, many of them distinguished members of our Society.

That any contributions of mine towards this object have met with the approbation of the Society, is in itself a great reward; coupled, however, with the honour you have to-day paid me, it becomes a source of much higher gratification.

The President next handed the Murchison Medal to Mr. Warington W. Smyth, for transmission to the Rev. William Branwhite Clarke, M.A., F.R.S., F.G.S., and spoke as follows:—

Mr. Warington Smyth.—The Council of the Society has awarded the Murchison Medal and a portion of the Murchison Fund to the Rev. William Branwhite Clarke, F.R.S., of Sydney, Australia, in recognition of his remarkable services in the investigation of the older rocks of New South Wales, services which have led to a correct knowledge of the succession of the formations in that great country, and which have been of great value to the community.

Mr. Clarke's labours date back nearly half a century, and he had contributed several interesting essays on points of British Geology before he commenced his arduous work amongst the Coal-bearing strata of his adopted country. Influenced by the love of scientific investigation, and aided by a self-reliant and independent character, he surveyed those great depths of rock which brought the local names of Hawksbury, Wianamatta, and Newcastle before the geological world as land-marks in an apparently anomalous series of strata. His survey, the result of years of patient labour, was so exact, that, in spite of former unsparing criticism, it is now universally recognized as correct; and his deductions as to the relative value of marine and plant-bearing strata in estimating the ages of formations, though disbelieved in former years, have been proved to be consistent with facts since observed in Africa, India, and North America.

Mr. Clarke discovered that there were strata of marine limestones containing Carboniferous *Spiriferi* and *Producti*, and with which were intercalated beds of coal which presented a mixture of forms of plants. He noticed that there was no break in this great series of deposits, and that *Sigillariæ*, Calamites and Coniferæ, were associated with *Glossopteris* and other genera of Filices, which, had they been found in the typical area of England, would have denoted a Mesozoic horizon. Subsequent research by other observers in Queensland has produced corresponding results; and science therefore owes much to Mr. Clarke for the consistent and persistent manner in which he has upheld his opinions regarding the age of these Australian Carboniferous series. Labouring amongst the strata below the Carboniferous, Mr. Clarke discovered the presence of Silurian rocks by the existence in them of characteristic Trilobites and Corals, and noticed the unconformability of the Carboniferous to the underlying group; and even in those early days of his work he grasped the important idea that the geology of the typical area of Europe was not exactly comparable with that of Australia.

From his knowledge of the country and of the physical development of the Australian Cordillera, Mr. Clarke was able to enlarge upon the relations of the sedimentary and intrusive rocks, and this led to his discovery of the auriferous quartzites and detrital accumulations of the mountains within sixty or eighty miles of Sydney. Subsequently the possibility of the great north and south range of New South Wales being highly auriferous, was impressed upon him by his comparing these mountains with the details of the Oural, the result of the labours of the great geologist, donor of this Medal, and Keyserling and De Verneuil.

Mr. Clarke's last work on the Sedimentary Formation of New South Wales appeared in 1875, and in it the veteran geologist had the satisfaction of repeating those acknowledged truths which he had elaborated thirty years since.

In asking you to forward this Medal to the Rev. William B. Clarke, I know that I am requiring a pleasant task at your hands, especially when I desire you to express to him the appreciation in which his labours are held by this Society.

Mr. Warington W. Smyth replied:—Mr. President,—It is with much satisfaction that I receive this Medal, to be forwarded to the Rev. Mr. Clarke, one among the oldest Fellows of the Society, who joined its ranks upwards of fifty years ago, and has since that time to the present continued his labours in the field of science. Although not personally acquainted with Mr. Clarke, I have had the opportunity, from his being a constant and valued correspondent of our late friend Sir Roderick Murchison, to hear much of the laborious researches carried on by our Medallist in New South Wales. I feel assured that the award of this honour will be duly appreciated in the colony, the Geology of which has been so much advanced by Mr. Clarke, and trust that it will be a source of pride and pleasure to the veteran explorer in his declining years.

In presenting the balance of the proceeds of the Murchison Geological Fund to the Rev. J. F. Blake, M.A., F.G.S., the President said:—

Mr. Blake,—In presenting you with the balance of the Murchison Geological Fund in the name of the Council of this Society, I have to express to you our appreciation of the excellence of the Geological and Palæontological services which you have rendered to science during the last few years. The Mesozoic formations of England which you are still investigating, require all the energies and accomplishments of the palæontologist for their elucidation, besides a great knowledge of practical field-geology. You have undertaken a great task in their description, and I trust that this slight expression of the approbation and sympathy of your fellow-geologists may urge you on in your laborious path.

Mr. Blake replied as follows:—Mr. President,—I beg to thank the Council very sincerely for the honour they have done me in making this award, and you, Sir, for the kind manner in which you have presented it to me. I do not know that there is anything that I care for more than the spread and advancement of our knowledge of Nature; and there is no honour I covet more eagerly than such as show, as I take it this does, that I have to some extent succeeded in doing something towards this end. I think I may conscientiously say that what geological work I have done has been the best I have known how to do, or have had the opportunity of doing, though I am continually learning how very much better that best might have been. With regard to the Mesozoic rocks, which form so prominent a feature in English Geology, there is very much yet to be learnt; and the hard and fast lines of the earliest observers have yet to be smoothed down and shaded off, by a study of the physical conditions of the deposits, before we have a complete and artistic picture of the whole. You have assured me, Sir, that the present award is meant not only as an honour but as an encouragement and incentive to me to go on and add, if possible, something more to the picture; and I hope the future may prove that I have received it in that sense.

The President next handed to Professor Ramsay, F.R.S., the Lyell Medal and part of the Lyell Fund, for transmission to James Hector, M.D., F.R.S., Director of the Geological Survey of New Zealand, and addressed him as follows:—

Prof. Ramsay,—The Lyell Medal I have the pleasure of asking you to forward, on the part of the Council of this Society, to James Hector, M.D., F.R.S., Director of the Geological Survey of New Zealand. It is given to him in recognition of his long and valued services in Geology and Palæontology both in British North America and in New Zealand. Seventeen years ago Dr. Hector communicated a valuable Report to the British Association for the Advancement of Science on the Geology of the Palliser Expedition, and others on the Physical features of British North America, and on the climate of the Saskatschewan district; and in 1861 this Society published his able paper on the Geology of Lake Superior. Having gained great experience as an accomplished surveyor, he commenced his celebrated survey of New Zealand, and the results of it have been to place the geological formation of those remarkable islands plainly before the world. His Geology of Otago, the Reports of the Survey, and his Geological Map of New Zealand—works of great importance—are most valuable contributions to our science. A distinguished naturalist, Dr. Hector has contributed largely to the Botany of New Zealand and to the study of its river-fish, which have remarkable affinities; as a palæontologist, he has not only described the fossil remains of the gigantic birds, but also of the extinct Reptilia of the islands. Impressed with the volcanic phenomena still in action, he has studied and written upon the thermal springs, the extinct volcanos, and the earthquake phenomena. He has been able to compare the grand developments of the formations of the islands with the European types; and his labours have ever been influenced by that method of research which rendered the founder of this Medal so illustrious.

Prof. Ramsay, in reply, said:—Mr. President,—I have very great pleasure in receiving this Medal for Dr. Hector, not only on account of his great distinction, but also because we have both been so much engaged in questions of Physical Geology. As a Physical Geologist, I regard him as standing in the very first rank; and his qualifications have been shown, not only in North America, but also by his thorough organization of the Geological Survey of New Zealand, which, under his charge, has attained a position second to none in the world. In Dr. Hector's name I beg to thank the Society for this testimony of its appreciation of his labours.

In handing the balance of the proceeds of the Lyell Fund to the Rev. Thomas Wiltshire, M.A., F.L.S., F.G.S., for transmission to Mr. William Pengelly, F.R.S., F.G.S., the President said:—

Mr. Wiltshire,—The Council of the Society have awarded to Mr. Pengelly the balance of the proceeds of the Lyell Fund, I may say unanimously, as an evidence of their thorough appreciation of his long and successful labours in the Geology of Devonshire, and his untiring devotion to the great task of extending scientific knowledge relating to the antiquity of man. By his systematic survey and labour in Kent's Cavern, especially, he has not only excited attention on this important subject, but has elaborated facts which will last as long as science. Thanks to his great energy and perseverance, he has kept up a love for geological science in his county; and this has been mainly due to the results of his work among the rocks of Devonshire. In presenting this fund to you for transmission to Mr. Pengelly, I feel that the good opinion which his fellow-geologists have of him and his work cannot be sufficiently expressed by me; but I trust that this recognition of his services to science will be felt by him as a slight reward for many years' arduous devotion to Geology.

Mr. Wiltshire replied:—Mr. President,—It is a subject of regret to Mr. Pengelly that he is prevented by public engagements from receiving to-day in person the award of the Lyell Trust Fund. Mr. Pengelly, while deputing me to be his representative, has begged me to convey to the Society his high appreciation of the honour conferred upon him. The award, he writes, seems to bring him once more into communion with the spirit of his old friend the founder of the trust, and will be an additional motive for still following up those investigations in Kent's Cavern and in the county of Devonshire which so long were approved of by the late Sir Charles Lyell.

The President then handed the Bigsby Medal to Mr. Hulke, F.R.S., F.G.S., for transmission to Prof. O. C. Marsh, F.G.S., and addressed him as follows:—

Mr. Hulke,—The Council of this Society have awarded the Bigsby Medal to Prof. O. C. Marsh, F.G.S., of Yale College, Connecticut, U.S., and I trust that in forwarding this testimony of our admiration of his abilities and work, you will explain to him that, being a Fellow of the Society, we cannot enrol him amongst our Foreign Correspondents and Members, but that we can offer him the first medal given by one who has laboured long and successfully in the field of American Geology.

The Medal is given in recognition of the great services which Prof. Marsh has rendered to the palæontology of the Vertebrata. He has distinguished himself by studying the fossil remains of nearly every great group of the Vertebrata from the Palæozoic, Cretaceous, and Cainozoic strata of the New World. The field of his research has been immense, but it has been very correct; and his descriptive and classificatory palæontological work indicates his effective grasp of anatomical details, and his great power as a comparative osteologist.

Prof. Marsh's early work was upon an Enaliosaurian from the Coal-formation of Nova Scotia; but this limited field of vertebrate research was soon left for the fossils of the wonderful country in the western territories of the United States. The Cretaceous series yielded the remarkable fossil birds, whose examination has been due to Professor Marsh; he added to the knowledge of the Pythonomorpha from the same series by distinguishing the pelvic girdle and the hind limbs. The Pterodactyles have been his especial study, as have also the Mosasaurs of New Jersey and the *Tylosauri* and *Lestosauri* of Kansas. The fossil fish of the Niobrara group have been in part worked out by him. Interesting and important as have been these researches in the lower vertebrates, they are surpassed by Prof. Marsh's palæontological contributions regarding the Mammalia of the post-Cretaceous ages. He has described some of the Oreodontidæ, those interesting Artiodactyles of the Miocene of Oregon; and he has illustrated and contributed to our knowledge of the Perissodactyles of the so-called Eocene of the western territories of his country, the genera *Palæosyops*, *Limnohyus*, *Lophiodon*, *Hyrachyus*, and *Limnotherium* being especially studied. His researches amongst the Dinoceratidæ are familiar to every geologist, and most anatomists will admire his labours amongst the fossil Rodentia. Prof. Marsh, moreover, has paid great attention to and described fossil species of Crocodilia, Lacertilia, and Glyptosauria, from the same series of strata, whose stratigraphical position is still a matter of debate. I trust that you will, as a brother palæontologist labouring somewhat in the same field, express to Prof. Marsh the appreciation we all *have of his interesting* and valuable contributions to our science.

Mr. Hulke replied:—I cannot doubt, Sir, that the award of this Medal will afford Prof. Marsh the highest satisfaction. His services to Palæontology have just been so fully enumerated by yourself as not to leave me anything to add in his behalf; they are so numerous and so important as to mark an epoch in this line of research. The present recognition of the value of his labours will doubtless prove an incentive to fresh work.

The President then proceeded to read his Anniversary Address, in which he referred to the fact that the strict uniformitarianism of former days is giving way to a school which insists upon the recognition of a scientific cosmogony, and attempts the explanation of the gradual evolution of the globe. He noticed the characters of the great curves of the surface produced by the earliest contractions of the globe in cooling, and especially discussed the effect of the forces to which the curving, folding, reversing, and upheaval of rocks are due, in the production of heat below the surface of the earth, and the manifestations of this interior heat in vulcanicity and metamorphism. He also referred to the rate of formation of deposits, the necessary extension of geological time, the conditions of denudation, the extent and cosmical relations of the atmosphere of our earth, and the effects upon geological phenomena of a probably higher and more abundant atmosphere in past ages. Stratigraphical geology, he remarked, has become synthetic; and instead of seeking for sharp breaks between formations, characterized by universal destructions of existing and creations of new forms, geologists now seek for evidence of the continuity of geological phenomena, the so-called "passage-beds" being recognized as not geological anomalies, but links in the chain of evidence regarding the variety of the synchronous changes on the surface of the earth, and of the irregularity and localization of the grand movements of its crust. These statements were illustrated by reference to various formations in different parts of the earth. The President also briefly discussed the modern doctrine of the origin of organic forms by descent with modification. The Address was prefaced by some obituary notices of Fellows and Foreign Members deceased during the past year, including Prof. Ehrenberg, Baron von Waltershausen, Prof. Brongniart, Mr. E. Billings, Dr. H. C. Barlow, Dr. H. Credner, Mr. T. G. Wyndham, and Mr. David Forbes.

The Ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—*President:* Prof. P. Martin Duncan, M.B., F.R.S. *Vice-Presidents:* Sir P. de M. Grey-Egerton, Bart., M.P., F.R.S.; R. Etheridge, Esq., F.R.S.; John Evans, Esq., F.R.S; Prof. J. Prestwich, M.A., F.R.S. *Secretaries:* J. W. Hulke, Esq., F.R.S.; Rev. T. Wiltshire, M.A. *Foreign Secretary:* Warington W. Smyth, Esq., M.A., F.R.S. *Treasurer:* J. Gwyn Jeffreys, LL.D., F.R.S. *Council:* H. Bauerman, Esq.; Rev. T. G. Bonney, M.A.; W. Carruthers, Esq., F.R.S; Prof. W. Boyd Dawkins, M.A., F.R.S.; Prof. P. Martin Duncan, M.B., F.R.S.; Sir P. de M. Grey-Egerton, Bart., M.P., F.R.S.; R. Etheridge, Esq., F.R.S.; John Evans, Esq., F.R.S.; Henry Hicks, Esq.; W. H. Hudleston, Esq., M.A.; J. W. Hulke, Esq., F.R.S.; J. Gwyn Jeffreys, LL.D., F.R.S.; Prof. J. W. Judd; Prof. T. McKenny Hughes, M.A.; Prof. J. Morris; Prof. J. Prestwich, M.A., F.R.S.; R. H. Scott, Esq., M.A., F.R.S.; Earl of Selkirk, F.R.S.; Samuel Sharp, Esq., F.S.A.; Warington W. Smyth, Esq., M.A., F.R.S.; Admiral T. A. B. Spratt, C.B., F.R.S.; Rev. T. Wiltshire, M.A., F.L.S.; Henry Woodward, Esq., F.R.S.

III.—February 21st, 1877.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.—The following communications were read:—

1. "On Possible Displacements of the Earth's Axis of Figure produced by Elevations and Depressions of her Surface." By the Rev. J. F. Twisden, M.A., Professor of Mathematics in the Staff College. Communicated by John Evans, Esq., F.R.S., F.G.S.

The object of this paper is to discuss the question of the possibility of a displacement of the earth's axis of figure under the conditions indicated in a question (suggesting the possibility of a displacement of the axis of figure from the axis of rotation amounting to 15° or 20°) put to mathematicians in a passage of the Anniversary Address, delivered to the Geological Society, by its President, J. Evans, Esq., on the 18th February, 1876. The treatment of the question is kinematical; the forces by which the elevations and depressions might be effected do not come under discussion. In determining numerically the amount of the deviation from the formulas investigated, approximate numbers seem to be sufficiently exact for every useful purpose. The conclusions arrived at are as follows:—

(1) The displacement of the earth's axis of figure from the axis of rotation that would be effected by the elevations and depressions suggested in the question above referred to, would be less than 10′ of angle.

(2) A displacement of as much as 20° could be effected by the elevations and depressions of the kind suggested only if their heights and depths exceeded by many times the height of the highest mountains.

(3) Under no circumstances could a displacement of 20° be effected by a transfer of matter of less amount than about a sixth part of the whole equatorial bulge.

(4) Even if a transfer of this quantity of matter were to take place, it need not produce any effect, or only a small effect, on the position of the axis of figure, *e.g.* if it took place in a way resembling that suggested in the question, it would produce a displacement amounting to but a small part of 20°.

(5) If, however, we suppose a deviation of the axis of figure from the axis of rotation amounting to as much as 20° to have been by any means brought about, the effect would be to cause a sort of tidal motion in the ocean, the greatest height of which would tend to be about twice the depth of the ocean. The author suggests as probable that the effect of this tendency would be to cause the ocean to sweep over the continents in much the same way that a rising tide sweeps over a low bank on a level shore.

(6) The notion that a large deviation of the earth's axis of figure from its axis of revolution may be effected by elevations and accompanying depressions is at first sight an inviting way of bringing polar lands into lower latitudes, and thereby accounting for the more genial climate that is believed to have once prevailed in such countries as Greenland. The investigation by which the above results have been obtained seems to show that the desired explanation is not to be sought in the direction indicated by Mr. Evans's question. Whether there is any other agency by which a gradual displacement of the pole geographically could be effected is a question of far wider scope than that discussed in the present paper, and one which the author does not profess to determine.[1]

DISCUSSION.—Mr. EVANS was willing to admit that in his Address he had somewhat overstated the amount of change in the position of the polar axis which was likely to result from the supposed belts of elevation and depression. When, however, he was told that the displacement would not exceed ten miles, notwithstanding his implicit faith in mathematics, there arose an inward feeling of disbelief as to the conditions of the problem having been accurately stated in order to obtain such a result. It seemed to him that the author had treated the globe as an absolutely solid spheroid instead of a terraqueous globe, with the proportions of land and sea upon its surface as at present existing, which were important elements in the case.

The depth of the ocean in equatorial and polar regions ought surely to be taken into account, as it was quite possible to conceive of the irregularly-shaped solid portion of the globe projecting in places through a spheroidal coating of water, so as to form large tracts of land, and yet on the average forming a sphere. Such a sphere, from disturbances of its equilibrium, he believed would be much more liable to changes in its axis than a spheroid, and the nearer a spheroid approached a sphere, the more sensible it would become to such disturbances.

He had never intended to suggest that the hypothetical belt was to be suddenly elevated so as to produce the enormous tidal movements of which the author spoke. On the contrary, he believed that all such disturbances of equilibrium were gradual, and that the axis of rotation and that of figure were never at any great distance from each other. There was one portion of the paper which he found difficult to comprehend. He could not conceive why so enormous a protuberance as 125 miles over a belt 20° in width should be necessary in order to displace the polar axis by 20°, when the present equatorial protuberance was only about one-tenth of that height.

Moreover, the probability is that the earth, instead of being a rigid solid, is to a certain extent viscous or plastic, and that such should be the case seems quite in accordance with geological facts. If the globe were a viscous body, with a solid crust of moderate thickness, elevations such as suggested in the Address might well suffice to bring about a shifting of the crust, either by sliding on the fluid or viscous interior, or by causing it to undergo a certain amount of gradual deformation. The thinner the crust, provided it were sufficiently rigid to support the elevations once made upon it, the more readily would its geographical position be changed with regard to the poles. With regard to the thickness of the crust at the present time, he did not despair of astronomers at last conceding a less thickness than that assigned by the late Mr. Hopkins and Sir William Thomson. He was glad to find that the latter, in his Address to the Mathematical Section of the British Association at Glasgow, was willing not merely to admit, but to assert as highly probable, that the axis of maximum inertia of the earth and the axis of rotation, always very near one another, may have been in ancient times very far from their present geographical position, and may have gradually shifted through 10, 20, 30, 40, or more degrees, without at any time any perceptible sudden disturbance of either land or water.

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[1] The first draught of the paper, of which the above is an account, was drawn up last August, and was shortly after sent to Mr. Evans. It was written independently of the wider view of the subject taken by Sir W. Thomson in his Address delivered at the last Meeting of the British Association, and by Mr. G. Darwin in his paper, of which an abstract has been published in No. 175 of the Proceedings of the Royal Society.

Mr. George Darwin, also no mean mathematician, in his paper recently communicated to the Royal Society, agrees as to the probability of large geological changes affecting the position of the poles, and regards the effect of such changes as possibly cumulative.

Mr. Evans felt that the Society was much indebted to Mr. Twisden for having likewise investigated the question, in which, of course, he was personally much interested.

Prof. Ramsay referred to the former prevalence in Geology of views which had long since been exploded, and expressed his opinion that before long the theory of the fixed geographical position of the poles of the earth would share the same fate, and that the position of the poles would be regarded as very variable indeed. The Flora of various deposits in Polar lands indicated the growth of plants which would require the stimulus of light, even if the necessary amount of heat for their growth could be accounted for. With respect to great local changes of level, he remarked that the northern part of Africa was 4000 feet below the level of the sea in very recent times, and there was considerable reason to suppose that even later than the Miocene a vast tract of land occupied the space between what were now the continents of Africa and India. Of course no one supposed that the position of the poles had been changed by rapid upheavals of land; but as we know that all geological changes of level have been slow and gradual, so the poles may have altered their position by a process as slow as that of evolution which has originated the species of animals and plants during the long series of geological time. Such questions as these were serious questions involving the results of much observation, and could not, he thought, be solved in the closet by any amount of geological work.

Prof. T. McKenny Hughes, Mr. A. W. Waters, the Rev. J. F. Blake, and Prof. Seeley, also took part in the discussion, and the author briefly replied.

2. "Note on a Specimen of *Diploxylon*, from the Coal-formation of Nova Scotia." By J. W. Dawson, LL.D., F.R.S., F.G.S.

The author described the occurrence in Coal-measure sandstone at the South Joggins of an erect stump of a Sigillarian tree 12 feet in length. It originated in a coaly seam 6 inches thick, and terminated below in spreading roots; below the coal-seam was an under-clay 3 feet 4 inches thick, separating it from an underlying seam of coarse coal. The stem, which tapered from about $2\frac{1}{4}$ feet in diameter near the base to $1\frac{1}{2}$ foot at the broken end, was a sandstone cast, and exhibited an internal axis about 2 inches in diameter, consisting of a central pith cylinder, replaced by sandstone, about $\frac{3}{4}$ inch in diameter, and of two concentric coats of scalariform tissue, the inner one $\frac{1}{25}$ inch in thickness, the outer constituting the remainder of the axis. The scalariform tissue of the latter was radially arranged, with the individual cells quadrangular in cross section. A few small radiating spaces partially filled with pyrites obscurely represented the medullary rays, which were but feebly developed; the radiating bundles, passing to the leaves, ran nearly horizontally, but their structure was very imperfectly preserved. The cross section, when weathered, showed about twenty concentric rings; but these under the microscope appeared rather to be bands of compressed tissue than true lines of growth. The thick inner bark was replaced by sandstone, and the outer bark represented by structureless coal. On a small portion of one of the roots the author traced the remains of stigmarioid markings. From the above characters the author identified this tree with *Diploxylon* of Corda, and stated that it was the first well-characterized example of this type of Sigillarians hitherto found in Nova Scotia. The author compared the structure of this stem with that of other Sigillarians, and remarked that it seemed to come within the limits of the genus *Sigillaria*, but to belong to a low type of that genus approaching *Lepidodendron* in structure; those of the type of *S. elegans*, Br., and *S. spinulosa*, Renault, being higher in organization, and leading towards the still more elevated type described by him in 1870. He further discussed the supposed alliance of these trees with Gymnosperms, and the probability of the fruits known as *Trigonocarpa* being those of *Sigillaria*, and expressed the opinion that the known facts tend to show that there may be included in the genus *Sigillaria*, as originally founded, species widely differing in organization, and of both Gymnospermous and Acrogenous rank.

IV.—March 7, 1877.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Beds between the Gault and Upper Chalk, near Folkestone." By F. G. Hilton Price, Esq., F.G.S.

The author described the characters presented by the beds between the Gault and Upper Chalk near Folkestone, indicated the fossils contained in them and their range in this division of the Cretaceous series, and discussed the classification of the deposits, and their equivalence with those recognized by other writers. His conclusions are shown in the following tabular arrangement:—

C. Barrois.			Author's divisions and zones.	F. Drew in Whitaker's Survey Memoir.	D'Orbigny.
			Upper Chalk.		
	Craie marneuse à *Ter. gracilis*, about 75 feet.	Lower Chalk with *Inoceramus labiatus*.	IX. Zone of *Echinoconus subrotundus* and *Terebratulina gracilis*, 118 ft.		Turonian, 150 feet.
	Craie noduleuse à *Inoc. labiatus*, 75 feet.		VIII. Zone of *Cardiaster pygmæus*, 32 feet.	Concretionary ? nodular chalk, 73 feet.	
	Bel. plenus zone proper.	Grey Chalk.	VII. Zone of *Belemnites plenus*, 4 ft.	Soft bed of 6 ft. with Belemnites, Whitaker, p. 33.	Cenomanian, 197 feet.
Craie à *Holaster subglobosus*.	Zone à *Bel. plenus* (Craie compacte).				
	Craie argileuse avec bancs durs à *Amm. Rhothomagensis*.		VI. Zone of *Holaster subglobosus*, 148 feet.	White chalk without flints, 138 feet.	
	Zone à *Amm. varians*.		V. 2ft. 9in. IV. Zone of *Amm. Rhothomagensis*, 11ft. III. 8½ feet.		
	Craie marneuse à *Plocoscyphia mæandrina*.	Chalk Marl.		Chalk marl, thickness not given; say about 30 feet.	
	Marne sableuse = zone of *Pecten asper*, or Warminster beds.		II. Zone of 10 ft. 1. *Plocoscyphia mæandrina*. 14 feet.		
			Upper Gault.		

2. "On the Vertebral Column and Pelvic Bones of *Pliosaurus Evansi* (Seeley), from the Oxford Clay of St. Neot's, in the Woodwardian Museum of the University of Cambridge." By Harry Govier Seeley, Esq., F.L.S., F.G.S., Professor of Geography in King's College, London.

In this paper the author described some bones obtained by J. J. Evans, Esq., in the lower part of the Oxford Clay at Eynsbury, near St. Neot's. They consisted of thirty-seven vertebræ, twenty-one of which are cervical, and apparently complete that series. These presented the characters of the cervical vertebræ of the typical Pliosaurs of the Kimmeridge Clay. The remains of the pelvis included a pubic bone showing a close correspondence in form with those of the Pliosaurs of the Kimmeridge Clay of Ely, and an ischium.

3. "Supplementary Notes on the Fauna of the Cambridge Greensand." By A. J. Jukes-Browne, Esq., B.A., F.G.S.

This paper was supplementary to one communicated to the Society by the author in 1875, in which he maintained that the Upper Greensand does not extend further in a north-westerly direction than West End Hill, near Cheddington, in Buckinghamshire, that the Cambridge Greensand is merely a nodule-bed at the base of the Chalk Marl, resting unconformably upon denuded Gault, to the upper part of which the greater portion of the fauna belongs, and that the remainder of the Fauna, belonging to the deposit itself, consists of species proper to the Chalk Marl rather than to the Upper Greensand. The object of the paper was to indicate certain additions to, and corrections in, the list of fossils upon which these conclusions were supported. The following Gault species were indicated as not previously identified in the Cambridge Greensand:—*Nautilus arcuatus*, Desh.; *N. inæqualis*, Sow.; *Turrilites elegans*, D'Orb.; ? *T. Emericianus*, D'Orb.; *Ornithopus histocheila*, Gardn.; *Brachystoma angularis*, Seeley; *Turbo Pictetianus*, D'Orb.; *Pleurotomaria regina*, Pict. & Roux; ? *P. Itieriana*, Pict. & Roux; *Pecten Raulinianus*, D'Orb.; *P. subacutus*, D'Orb.; and *Lima Rauliniana*, D'Orb. The author described as new species: *Turrilites nobilis*, *Nautilus*, sp. nov., *Natica lævistriata*, *Nerita nodulosa*, and *Lima interlineata*, and noted several corrections in the nomenclature adopted in his former list.

CORRESPONDENCE.

THE FOSSIL FLORA OF THE TERTIARY BEDS OF BOURNEMOUTH.

SIR,—As Mr. Gardner admits that the vegetation of the Bournemouth beds is drifted, the question seems to resolve itself into one of extent. This he thinks he can measure, and pronounces to be very limited. I, on the contrary, venture to doubt that there is anything in the state of this vegetation repugnant to its having travelled various, and in some cases considerable, distances. He insists that the leaves have never been drifted from afar, because of their perfect condition, and because they are often adherent to the twigs; and he adds that "the forms of most temperate aspect are best preserved, so that, to be logically applied, the Drift theory requires the palms, etc., to have been drifted upwards." Now I fail (and I think that your readers will fail also) to perceive any logic in the matter. Short tributaries descending from elevated regions at no great distance would necessarily have a very swift current; and the vegetable spoil of those regions would in consequence be carried far more quickly, and in better condition, towards the place of its deposit than would much of that carried by the main river and by those tributaries which flowed with more sluggish currents through longer tracts of low ground, and brought "the palms, etc."

Mr. Gardner, after intimating that I appear to be totally unacquainted with the subject, observes that the Fauna of the Thanet sands, Woolwich beds, London Clay, Bracklesham, Headon, Bembridge, and Hempstead beds,[1] make it plain to us that the climatal conditions during the deposit of our Eocene series differed widely at each period. Now my acquaintance with the Eocene formation, and with its Fauna in various ways,[1] is somewhat more than Mr. Gardner gives me credit for; and I distinctly traverse his suggestion that the Fauna of the beds he names affords (when allowance is made for varying conditions of bottom and depth, and for the difficulty in making comparisons between faunas of which some are marine, some fluvio-marine, and some fluviatile, as is the case with these beds) any indication whatever of a diversity of climate. Fortifying the opinion which I have formed from my own acquaintance with these beds, and with their Fauna, by that to the same purport of my father, who has made the study of the Tertiary Mollusca the occupation of the greater part of a long life, I contend that, so far as the past can be judged from what is known of the present, this fauna is of tropical character throughout. It was once thought that the mollusca of the Thanet sands indicated a colder climate than did those of the beds which succeed it, but the subsequent discovery of a Nautilus in these sands has made even that view difficult to be maintained. Moreover, not only do the Eocene beds of Western Europe present this character, but the close similarity between Eocene mollusca found in the Aral-sea region and those from the English and French beds indicates that this climate prevailed under nearly the same latitude as far, at least, as the meridian of 60° East longitude.

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[1] The Hempstead beds are not usually regarded as Eocene.

I have trespassed thus much on your space, to vindicate the opposition which I offered to Mr. Gardner's hypothesis of oscillations of climate during the Eocene period; and I could pursue the subject further, as well as offer reasons for disagreeing from his alternative theory of the existence of a mean annual temperature, which permitted the growth of sub-tropical and more temperate forms side by side; but as he expresses his intention of not entering into any discussion with me, this would be undesirable, as I should be sorry to tempt him into any descent from the serene elevation on which he has placed himself.

I would, however, observe that, although the explanation which I offered as to the Hampshire Flora seemed to me the most obvious in that particular case, and although I do look upon both of Mr. Gardner's hypotheses as remote from the truth, I have nothing to say in opposition to Prof. Heer's view that difference of climate according to latitude did not, so far as it is evidenced by fossil vegetation, begin to show itself until late in the Mesozoic division of the Earth's history.

SEARLES V. WOOD, Jun.

THE GONDWANA SERIES OF INDIA.[2]

SIR,—I have some remarks and corrigenda to add to my article on the Gondwana Series of India.[3]

First, as regards the classification of the whole area, as used in the above-mentioned paper, I have to state that it should be, properly, as follows:

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[1] Amongst them, the original and first disinterment from the Hampshire cliff, in association with my father (now thirty-four years ago), of the remains of "Alligator, Turtle, and other Reptiles," to which Mr. Gardner in his paper refers.

[2] The publication of this letter has been by an unfortunate oversight delayed a month.—EDIT. GEOL. MAG.

[3] *See* GEOL. MAG. Dec. II. Vol. III. p. 481.

GONDWANA SYSTEM (not, as I wrote, "Gondwana Series").

a. Upper portion of the Gondwana System.

"Kachh-Jabalpúr Group" (not Kachh Series, as I wrote); "Rajmahal Group" (not, as I wrote, Rajmahal Series),[1] etc.

b. Lower portion of the Gondwana System.

"Panchet Group"—"Damuda Series" (not, as I wrote, Damuda Group, as it consists itself of several groups, as, Kamthi-Ranigunj group, Iron-shales, Barakur Group: this, however, only stratigraphically).

"Talchir Group" (considered by me to be a lower portion of the Damuda Series).

In the chapter on the fossils of the Panchet Group (*l. c.* p. 486) I have to add that Prof. Huxley, although considering the vertebrate fossils as probably Triassic, found also some affinities with certain Permian forms; but the closest connexion is still with the Triassic (?) South African reptilian remains. And here, in India, we have, as additional evidence, throughout a Triassic (Keuperic) Flora, which leaves little doubt that our Panchet Group, in comparison with already known formations, is to be considered as what is termed in Europe "Keuper." This, of course, is not intended to prove that both are contemporaneous. It proves only identity of forms, and therefore the some homotaxial position.

I write this note especially because it should not seem that I have intentionally left out half of the arguments. I thought, however, to have said enough by referring to Prof. Huxley's important paper on the reptilian remains from the Panchet group, where he has himself so thoroughly discussed their affinities.

There are also some serious errata in the text, which should be corrected, namely:

On p. 485, line 5, *for* "with European Triassic forms," *read* "European Jurassic beds" (for the only beds in Kachh are Jurassic).

On p. 487, line 12, omit "perhaps" (because there are certainly similar forms in Africa).

On p. 489, line 33, for "*Pteroph. Carterianum*," read "*Pteroph. Morrisianum*."

Dr. OTTOKAR FEISTMANTEL,
Geol. Survey of India.

CALCUTTA, 14*th Dec.* 1876.

DR. FEISTMANTEL'S PAPER ON THE GONDWANA SERIES.

SIR,—Even a scientific controversy, if prolonged, tends to become less amicable than it should be, and I shall therefore not attempt to reply at length to Dr. Feistmantel's remarks in his paper on the Gondwana Series of India, published in the GEOLOGICAL MAGAZINE for November, 1876. I will only beg that any one who feels interested in the subject will do me the honour of consulting my original paper in the Records of the Geological Survey of India for 1876, pt. iii. pp. 79–85, because I do not think that a just idea of my views or of the objects of my paper will be derived from

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[1] This was the former collective name for the whole upper portion of the Gondwana system, as used by Dr. Oldham; but there are certainly several different groups.

Dr. Feistmantel's criticisms. Dr. Feistmantel suffers from the great disadvantage of writing in a foreign language, and I think he expresses himself sometimes more forcibly than he intends.

The object of my paper was to point out that Dr. Feistmantel had overlooked some of the arguments which had mainly influenced the opinions of those of his colleagues who had written upon the age of certain portions of the Gondwana series. I may have been in error on certain points, as on the question of the occurrence of Cycads in the Damudas, but I still think that Dr. Feistmantel's enthusiasm has led him to overestimate the arguments in favour of his own views, and to undervalue those which are opposed to his conclusions. I have no wish to insist upon an Upper Oolitic or Post-Oolitic horizon for the plant-beds of Cutch, and I am far from considering the Palæozoic age of the Damuda beds as proved; but I think that Dr. Feistmantel has argued, however ably, on one side of the case only, and that it was a mere act of justice to his predecessors to explain why they had come to a different conclusion.

My mistake about the occurrence of the *Cycadaceæ* requires a few words of explanation, the more so that Dr. Feistmantel evidently considers it of the greatest importance, for he calls attention to it in a marked manner no less than three times in two pages, so as to produce the impression that I had committed a most absurd blunder. I wrote, "Cycads have not hitherto been found in the latter," *i.e.* the Lower Gondwana rocks. Dr. Feistmantel replies, "Cycadaceous plants are not absent at all"; and he proceeds to enumerate three species, and he adds in a footnote referring especially to me, "they (*i.e.* Cycads) were indeed known long ago." Now what are the facts? Two of the three species enumerated by Dr. Feistmantel, viz. *Nöggerathia Vosgesiaca* and the *Glossozamites*, were, to the best of my knowledge, not even detected by Dr. Feistmantel himself till after my paper was written; certainly no notice of them was published, nor had Dr. Feistmantel called my attention to them. The third species, described by Sir C. Bunbury as *Nöggerathia Hislopi*, was, if I am not mistaken (I am writing at a distance from all books of reference), referred with doubt to the genus; and *Nöggerathia* certainly was not formerly classed as a Cycad; still Dr. Feistmantel may be right in referring it without any doubt to the *Cycadaceæ*, and all I have to say in apology is that I was not aware that the Cycadaceous nature of the genus had been ascertained. I think this explanation is necessary, and it is to be regretted that Dr. Feistmantel, by omitting to state all the facts, has compelled me to make it.

W. T. Blanford.

Camp, Sind, *February 1st*, 1877.

MR. CARPENTER ON THE PLANET MARS.[1]

Sir,—In the first paragraph of the first article of your last issue, Mr. Carpenter has exactly inverted the proper descriptions of Mr. Croll's and Mr. Murphy's theories. This no doubt was a slip of the pen. But when he goes on to say that it has occurred to him that he has ever seen in this discussion (on climate) any reference to the planet Mars, he ought to have added, that it had *not* occurred to him to look ut "Mars" in the index to "Climate and Time." O. F.

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[1] See the March Number, p. 97.

THE PILSEN PERMO-CARBONIFEROUS BEDS.

Sir,—In the extremely interesting paper on the Permo-Carboniferous beds of Bohemia which appears in the current number of the Geological Magazine, Dr. O. Feistmantel appears to rely very strongly on the announcement which he says was made by Dr. Anton Fritsch at the last meeting of the British Association that he considered the Nürschan Gas-coal horizon as a passage-bed from Carboniferous to Permian. Now when Dr. Fritsch exhibited his splendid series of specimens before the Geological Section, it was evident that he avoided carefully expressing any statement of opinion as to the exact age of the beds whence they came. A member then rose and asked Dr. Fritsch whether he considered the Pilsen Gas-coal series as Carboniferous or Permian, or whether he looked upon them as passage-beds. The only answer elicited from the cautious palæontologist was that it was not yet time to settle the matter, and that more work was required before the question was ripe for decision. In fact, he declined to give any clue as to what his views on the subject might be. The Questioner Himself.

8 *March*, 1877.

THE TERM "CHLORITIC MARL."

Sir,—In the review of Cambridgeshire Geology, by the Rev. T. G. Bonney, in your last Number, your reviewer takes exception to the use in that work of the term "Chloritic Marl" as applied to the Phosphatic Nodule-bed at the base of the Chalk-marl in Cambridgeshire and elsewhere. From this it would appear that there is some doubt about the proper use of the term, and I should be very glad to hear from your reviewer what he considers the true typical Chloritic Marl. The question of nomenclature is so important that I feel sure your readers will not regret the use of a small portion of your valuable space in clearing up a doubt which seems to exist on this subject. H. George Fordham.

Odsey, Royston, *March 5th*, 1877.

OBITUARY.

JAMES SCOTT BOWERBANK, F.R.S., F.L.S., F.G.S.,

PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY.

BORN JULY 14, 1797. DIED MARCH 8, 1877.

It is with no ordinary feelings of regret that we record the loss of the Founder and President of the Palæontographical Society.

James Scott Bowerbank was born in Bishopsgate, London, in 1797. He succeeded, in conjunction with his brother, to his father's distillery, in which business he was an active partner until 1847. From his youth he exhibited a strong attachment to Natural History pursuits, especially to Botany. When of age, he joined the Mathematical Society of Spitalfields, and remained a member until its incorporation with the Royal Astronomical Society in 1845. Here he became acquainted with many scientific men, and earnestly entered upon a course of Natural Science studies, which were steadily continued, although he was actively employed in a business demanding constant and careful attention for at least twelve hours daily. His pursuit of science was a labour of love, for at that period but little favour was bestowed either upon science or its votaries.

During the years 1822, 1823, and 1824, he delivered courses of public lectures on Botany, and later, in 1831, on Human Osteology.

About 1836 he formed, with F. E. Edwards, Searles V. Wood, John Morris, Alfred White, and N. T. Wetherell, "The London Clay Club;[1] the members of which devoted themselves to the task of examining the fossils of the London Clay, and making a complete list of the species.

In 1847, after the reading of a paper by Prof. Prestwich, at the Geological Society, "On the Structure, etc., of the London Clay," Bowerbank joined in the discussion, and in the tea-room, after the meeting, solicited the leading geologists present to support him in establishing a Society for the publication of undescribed British fossils. Buckland, De la Beche, Fitton, and others who were present, gave him their names, and thus originated the Palæontographical Society.[2]

In 1840 Bowerbank published a separate work, entitled: "On the Fossil Fruits of the London Clay," still the only publication in which these interesting remains have been described and figured.

In 1842 Dr. Bowerbank was elected a Fellow of the Royal Society. He contributed upwards of thirty papers to the various learned Societies, to the Annals Nat. Hist. and the Microscopical Journal. His scientific collections[3] were most extensive, comprising fossils from every geological horizon, many of which are figured in the various Monographs of the Palæontographical Society.

From 1844 to 1864 Dr. Bowerbank was in the habit of receiving once a week, at his residence in Park Street, and afterwards at Highbury Grove. On these occasions every youthful geological student found in him a willing instructor and a sincere and kind friend. The treasures of his Museum, the use of his microscopes, and his personal assistance, were at the disposal of every one.

Since his retirement to St. Leonard's, Dr. Bowerbank rarely visited London; only a few of his scientific friends have therefore been able to keep up a personal intercourse with him. Mr. Dinkel writes, "For the last six or nine months I have been with him daily, but there is little to mention save his fervent desire to finish his great work on Sponges. He employed almost all his time upon it, and begged me to remain till all the plates were executed. We reached *the last plate*, and when half of it was drawn, he became sadly depressed, and so weak that the finishing was postponed from day to day till his death. There will be no difficulty, however, in completing the work."

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[1] See Geol. Mag. 1875, p. 571.

[2] Extract of letter from Prof. Prestwich, F.R.S.

[3] It will be interesting to our readers to learn that, in 1864, Dr. Bowerbank's magnificent collection was purchased for the British Museum, and now forms part *of our National treasures.*

THE
EOLOGICAL MAGAZINE.
NEW SERIES. DECADE II. VOL. IV.

No. V.—MAY, 1877.

ORIGINAL ARTICLES.

I.—A VISIT TO THE VOLCANO OF OSHIMA.

By Professor JOHN MILNE, F.G.S.,
Imperial College of Engineering, Kogakurio, Tokei, Japan.

LOOKING at a map of Asia, or, still better, at a map of Japan,
there will be seen a string of islands stretching from near the
ntrance of the Bay of Yeddo in a more or less southerly direction
owards the Bonins. It is very probable that all these islands are
f volcanic origin. With the exception of one or two of them,
hich within the last few years have given off a few curling wreaths
f steam, they might strictly be defined as being dormant, having
iven vent neither to fire nor smoke within the history of their
habitants. In this respect they are similar to many of the volcanic
nes in Japan, with which they are also probably coincident in age.
short time ago, however, during the first week in January, a great
ange was observed in the most northern of these islands, which is
lled Oshima. Ships coming into Yokohama brought news that
e island was on fire. One captain reported that flames 200 feet
height were seen. Although Oshima was an island which three
ars previously had been giving out clouds of smoke, and seven
ars before that had been actually in eruption, it was thought by
any that the conflagration was due to the burning of grass or
ood, and it was not till some days had passed that the true state
affairs became fully recognized.

After some trouble, a party was organized and a steamer engaged
visit the scene of the eruption. We left Yokohama on the after-
on of the 19th January, and in the evening reached Kanasaki, a
llage situated at the extremity of the peninsula upon the south side
Yeddo Bay. After staying here a few hours, we continued our
urse, and reached the island shortly after daybreak on the follow-
g morning. During the night there was an uninterrupted view of
e volcano, from the summit of which huge clouds of steam, lighted
with the glow from the crater beneath, could be distinctly seen.
was a veritable "pillar of fire."

The island, which is about eight miles long, and very mountainous,
s only one harbour, and this is useless but for vessels of small
ze. It is called Habu, and is situated near the S.E. corner of the
land. It is entered by a narrow gap in cliffs of stratified and con-
rted agglomerate. This entrance is shallow, but the harbour itself

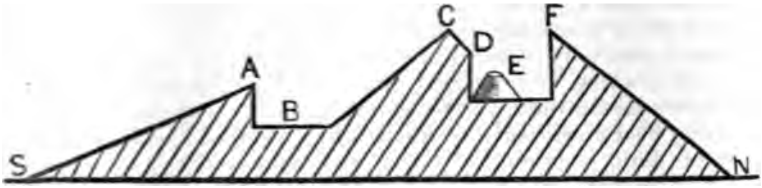
is about fifteen mètres or more in depth, and is surrounded by apparently almost perpendicular cliffs of stratified trachytic and brecciated rocks. It is in fact the crater of an old volcano, and is stated by the people of the island to have been first occupied by the sea about 100 years ago. About two weeks previous to this time I had been travelling round the province of Idzu, which is the nearest mainland to this island. Whilst there, I and my companion made several unsuccessful attempts to cross the ten or fourteen miles of water which separated us from this then inactive volcano. Japanese boatmen and junk-owners, however, thinking the weather too uncertain, we had to content ourselves with remaining on the mainland, and sketching the island from a distance. Both it and its southern neighbours showed many peaks, which, from their similarity to those in Japan, might be considered without much risk of error as being of volcanic origin. One thing which then particularly struck us was their barren appearance. In this I now found that we had been considerably mistaken, and that, at least at Oshima, there was a considerable amount of vegetation. All the sides of the harbour in which we lay were thickly covered with underwood and small trees, whilst in many places near the shore, some fair-sized pines rose to a considerable height.

Excepting birds, the Fauna of the island is represented by rats, mice, weasels, and snakes. At one time there was a large wild animal like a goat, but this has been exterminated by the Japanese natives. Foxes, and many other animals, which are so abundant on the mainland, do not exist. Frogs are also conspicuous by their absence, but this is probably owing to there being a scarcity of water on the island. In whatever way, however, this island may have been colonized since the time of its formation, both the Fauna and Flora are sufficiently large to guarantee the assumption that it is of a considerable age, which, as I have before stated, is probably that of the volcanic cones which so thickly cover the mainland.

From the people on shore we learnt that the eruption had commenced on the 4th of the month, and therefore it had been sixteen days in action. The only notice that they had of its outburst was a loud explosion, which was described as having produced a slight vibration. This appears to have been all that was felt of the nature of an earthquake, and so far as the inhabitants of the island were concerned, all was going on quietly. They told us that cinders were being thrown out of the crater, and that seven years previously, as I have before stated, there had been a similar eruption, which, however, only lasted two days. Twenty years before that they said it was always in eruption. Information, however, was difficult to obtain, and uncertain in its character. None of the inhabitants, although not more than four miles distant, had visited the crater, and, as we shortly afterwards found out, did not appear even to know the way to it.

Securing the assistance of six men, we set out by a zigzag road towards the top of the old crater, in which the village is situated and where our vessel was lying at anchor. The sides of this crater had, near the place where we ascended, an inclination of from 40° to 50°. We were soon amongst a network of small lanes and footpaths overshadowed with bamboo, alder, and other trees. Once or twice our path led up to a small water-course, the black ashes forming its bed becoming coarser and coarser as we ascended. Next we were ascending the course of an old lava-stream over black trachytic boulders. Then again we were in steep gullies and narrow lanes, the sides of which were made up of stratified beds of ashes, all dipping at various angles down towards the sea. Once or twice we reached a small open space, and obtained a view of the bare peaks towards which we were travelling. Whilst resting on one of these, we could distinctly hear a series of explosions, which sounded like the sudden escape of large quantities of steam, and we saw clouds of vapour rising from behind the nearest summit. After struggling along for nearly two hours, we found that the men we had engaged as guides did not know the road, and were leading us round the island rather than up towards the crater. Meeting with a lava-stream of tolerably large dimensions, which was filling the bed of a gully, I struck up along its course, expecting that it would lead to some crater or other on higher ground. At several points along its course we met with obstacles where the lava when molten had made a precipitous descent, like frozen waterfalls, which involved some tedious climbing and scrambling through the bushes, which thickly covered the almost perpendicular walls of the ravine on either side. The rock of this stream was trachytic, of a very dark colour, and extremely vesicular. I may here remark that most of the lavas in Japan appear to be trachytic. The general direction of the vesicles in the lava was that of the stream; but there were so many exceptions to this, owing to irregularities and obstacles in its course, that they could not be taken, unless seen as a whole, as indicating the original direction of the fluid matter. When lava flows over an even course, such deductions might possibly be made, even if the stream were only examined at one point along its course. In some places along the stream my companions observed the charred trunks of several trees which had probably been overwhelmed during its flow. That these trees still remained seemed to indicate that this stream must have been of recent origin. After about an hour's climbing, we were above the line of vegetation, and instead of trees and bushes being on either side of us, we now had hills of ashes. On one of them my friend Dr. Naumann met with beds of tufa, in which were impressions of plants, which, from some attached rootlets, appeared to have been buried where they grew. From the position of these beds and their contents it was evident that vegetation once extended much higher up the sides of the mountain than it does at present, and that it was probably destroyed by a volcanic outburst.

We now directed our course towards the highest peak before us (marked A in section), at the back of which we hoped to see something of the eruption. After a tough scramble through black, scoriaceous ashes, we reached the top, where we soon saw that we had much further to travel. We had in fact reached the rim of an old crater (B), whose sides at this point descended perpendicularly I should think, at least 400 feet. Walking along this rim, which was covered with large weather-worn whitish boulders, which looked not unlike material which had been torn from the perpendicular faces below us, we found a slope of ashes, down which we descended into the bed of the old crater. On looking at the face of the perpendicular cliffs from the top of which we had just descended, we saw they consisted of irregularly broken and contorted bands of a whitish rock like trachyte, more or less parallel. They were capped with beds of ashes. In these ashes, as in the most scoriaceous portions of the lava, crystals of a glassy felspar were very abundant. In the more compact lava they were absent, that is, to the naked eye. The rim of this old crater, although a serious obstacle on the side of our ascent, is not continuous round the mountain, and is only to be seen on the south and south-western side.



Approximate section of the upper portion of Oshima.

S—A, Outer slope of old crater-wall. (prehistoric?)
B, Floor of old crater, partly filled by later eruptions.
B—C, F—N, Outer slopes of modern crater-walls.
C,D,F, Rim of modern crater.
E, New volcanic cone formed by present eruption, January, 1877.

After collecting a few specimens of rock from a black-looking mass which was probably the throat of an old vent, we proceeded forwards to make the ascent of another cone of ashes (B C), which, from its position, was evidently that which remained of the eruption succeeding the one which formed the crater we were then leaving. The explosions we had heard when at a greater distance were now more audible, and occurred rapidly in succession. As we neared the top (C), which was about 800 feet above the plain from which we started, the noise, which was like that of immense jets of steam, was sometimes accompanied with a tremulous motion of the ground. It was not long before we reached the rim of the second crater (C), which we did to behold a sight defying my powers of description. Instead of looking up at a crater, we were looking down at one. Standing on the rim of crater C, before us there was a short descent of loose, black ashes, somewhat steeper than that up which we had climbed, terminating suddenly in perpendicular cliffs, which formed an amphitheatre of rocks about half a mile in breadth, the walls of which, upon the opposite side, were about 300 feet in height. At the bottom of this pit, on the side nearer to us, a small cone, with an orifice of about 50 feet in diameter, was belching masses of molten lava to a height more than double that at which we were standing.

The explosions, which varied in intensity, occurred about every 2 seconds, but sometimes there was a pause for 15 or 20 seconds. At the time a strong wind was blowing at our backs, which kept any of the lighter lapilli from driving in our direction. Coming, as we did, so suddenly upon the precipice-like edge of a huge black cauldron, roaring, shaking the ground, and ejecting a dense column of red-hot stones and ashes, the wild and dismal aspect of which was heightened by dark clouds, driving rain, and a heavy mist, produced at first a feeling of timidity, which was so strongly shown by our six so-called guides that it was with difficulty they were prevented from taking to precipitate flight.

The cone at the bottom of the cauldron before us, together with a large quantity of lapilli and bombs scattered over the ground on which we stood, were the result of 16 days' activity. Three years ago, in the place where this new cone now stands, there was a deep hole, from which steam was issuing.

The great interest in this eruption lay in the fact that we were able, on account of our position, to look down into the crater. In the intervals between the ejections the interior could be well seen, and it was observable that the sides had a slope of very nearly the same inclination as the exterior. Now and then large masses of these interior sides, which were black, would slide down towards the throat of the crater, and reveal a red-hot interior, showing that the cone itself was probably internally red hot throughout. One side of the cone had been blown away, leaving a breach, almost level with the plane from which it rose. This opening greatly facilitated our observations. Looking down into the crater on this side, molten lava, approximately level with the base of the cone, could be seen. At each explosion it rose in waves, and swayed about heavily like a huge basin of mercury, a little of it being apparently pushed forward through the breach to add to a small black-looking stream upon the outside. The explosions, which I have referred to several times as resembling outbursts of steam, might be compared to the escape of steam from a slowly-working non-condensing steam engine greatly magnified.

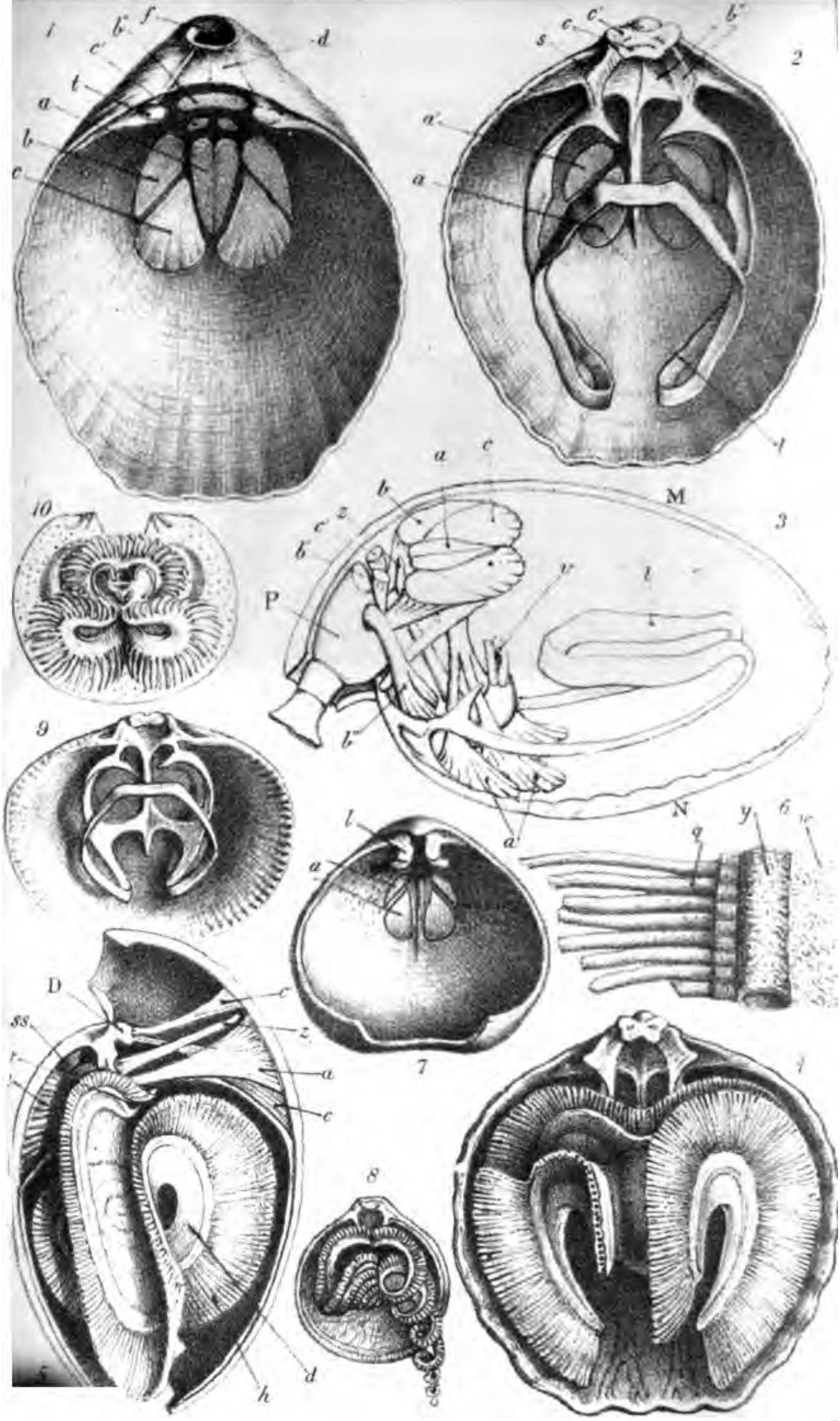
On listening attentively, a rattling could sometimes be heard, reminding one of stones and pebbles on a beach driven forwards and drawn backwards by the advancing and retreating surge. This I think could hardly be due to the churning of stones in the mouth of the crater, which was not only short, but it expanded upwards, forming a funnel-shaped opening. Nor was it in the throat of the crater; for, so far as I could see, that was filled with molten matter. It is, however, difficult to imagine it to be due to the contact of particles brought about outside the crater, which is the only place remaining to which the origin of the sound can be attributed.

Each explosion, as I have said, produced a fountain-like column of red-hot ashes and volcanic bombs. The height to which they sometimes rose must have been nearly 1000 feet. Many of them appeared to be of a feathery lightness. As they rose, their velocity became gradually less and less, until they seemed to pause and flo in mid-air, before turning to descend, which they did with a augmenting speed. The large masses only rose to a comparative small height. Many of the pieces fell upon the sides of the exteri of the cone from which they had been shot, where they at on created a small cloud of steam, and rolled a short distance down side to form a natural slope. As the material, which approximate fell vertically, increased in quantity, the angle of this slope wou naturally increase up to a certain point, because, where the slope short, any material that might fall upon its side has suffici momentum to roll to the base; but as the length of the sl increases, an element of friction is brought to play, which preve such action taking place. The direction in which the material shot up was generally vertical, but sometimes it had a little incli tion in a direction opposite to that in which we were standi Should the ejections from a volcano not be in an approximat vertical line, or during the time of its action winds should bl in one direction more than another, we might reasonably expect resulting cone, which would be formed by the falling material have a less steep inclination upon the side where the grea quantity of material had accumulated. Such actions may perh give some explanation to the slight differences in slope which are often to be observed in recent conically-shaped volcanic mounta This is of course presuming that the form of the mountain has been materially altered by subsequent denudation. Many of larger pieces often appeared to separate when in mid-air. This I not think was due to any explosion which took place within th but rather perhaps to some such cause as a sudden cooling.

Looking at some of these bombs, which had fallen on the le where I was standing, they appeared to have done so whilst still a pasty condition, because some of them showed a decided f tening, as if produced by impact. Both the bombs and lapilli wer a black colour, and pumiceous texture. Although I believe each these explosions to have been the result of a sudden bursting steam through the molten lava, I did not see any aqueous vap which I could recognize as having been evolved whilst I was stand near the crater. This may have been perhaps due to the inte heat keeping the vapour in an invisible state until it became hid in the fog and murky atmosphere which enveloped us.

Notwithstanding a strong ice-cold breeze blowing in the direct of the eruption, which was about 150 yards distant from us, effect of radiation was distinctly felt, especially when the ejec column of ashes was large.

Independently of variations, produced by unusually large e tions, two thermometers in boxes were each raised 3° C. so lon we remained in this position. This warmth was all that m our position bearable, as otherwise it was bitterly cold, wit sleety rain pouring down, and we were all wet through. O or twice a little fine ash fell upon us, and a slightly sulphure smell could be detected. The journey down the mountain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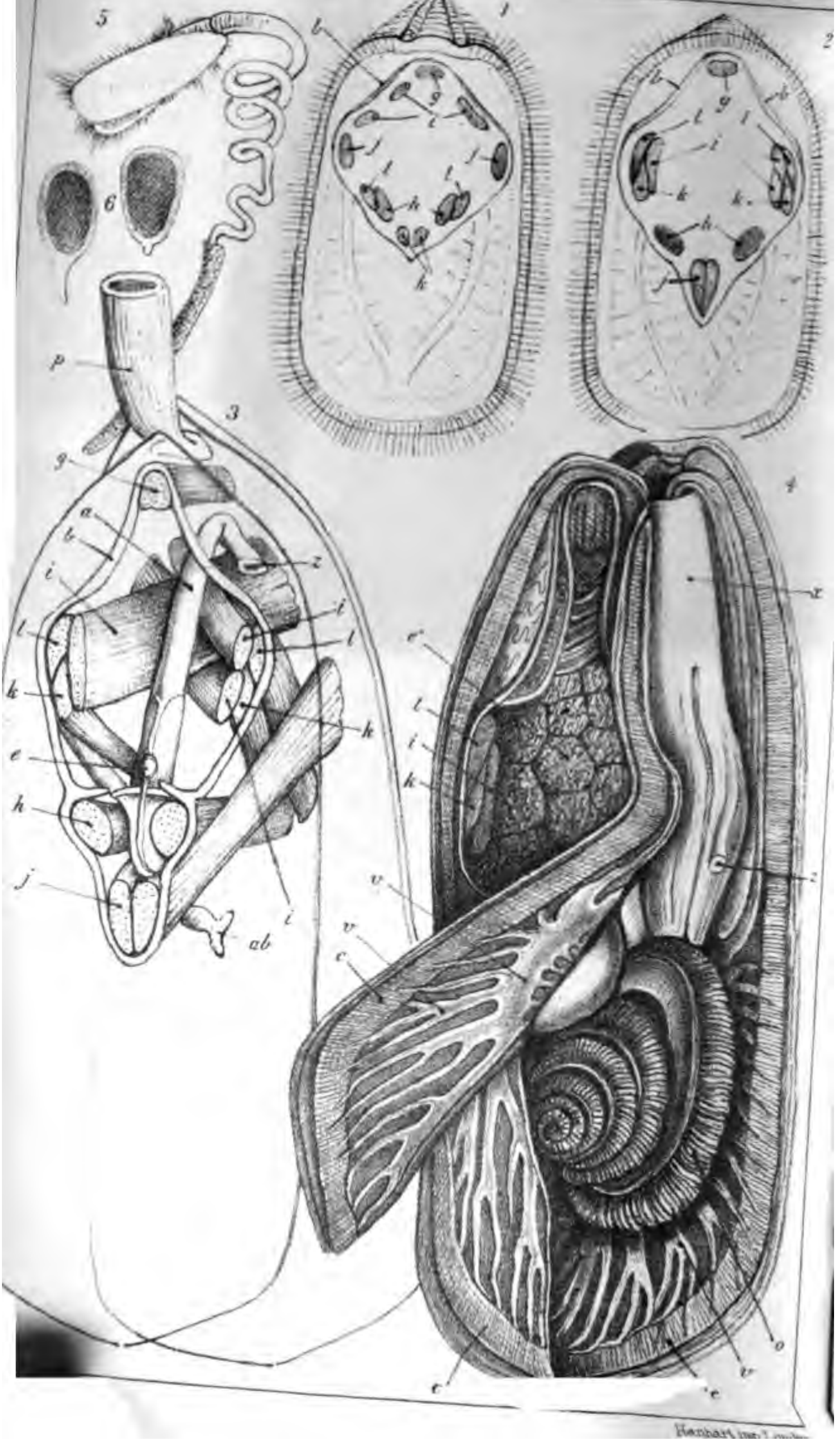

Hanhart imp.

accomplished in about two hours, which was half the time it had taken us to ascend.

From the inhabitants we learnt that the mountain is regarded as being holy, and that at certain seasons they make solitary pilgrimages to its summit. We, however, had been the first to see the eruption.

Earthquakes, although so common on the mainland, are said not to occur here; and the only shocks that have been felt are those which were produced at the time of the breaking out of the volcano. This statement appeared to find some confirmation in the fact of a strong earthquake having occurred in Yokohama and Yeddo at the time of our making our inquiries, without being perceived by us. Several other localities in Japan are reported as being free from such annoyances; but how far these statements may be relied on needs investigation. Some of these districts are in the neighbourhood of recently active volcanos. If it is admitted that in the immediate vicinity of certain active volcanos, earthquakes are unknown, whilst in the surrounding districts they are strongly felt, the idea would at once suggest itself that round these particular volcanos, conditions exist which ward off the advance of any seismic wave. Thus, for example, a lake of lava beneath the unaffected area might accept a wave, but, for want of proper contact with the the rocks above, would be unable to transmit its effect in their direction. Owing to the state of the weather, and the short time we remained upon the island, conditions were very unfavourable for making accurate observations.

Next morning we set sail for home, a distance which in coming had been traversed in only six hours; but in returning, through the roughness of both wind and water, occupied two days.

II.—What is a Brachiopod?

By Thomas Davidson, F.R.S., F.G.S., V.P.P.S.

PART II.

(PLATES IX. and X.)

(*Continued from the April Number*, p. 155.)

Muscles.—As the number and position of these organs differ materially in the two great divisions into which the Brachiopoda have been separated, and to some extent, also, in the different genera of which each division is composed, it may be desirable to treat this subject under two different heads.[1]

In the *Clistenterata*, of which the genus *Terebratula* may be taken as an example, five or six pairs of muscles are stated by Hancock, Gratiolet, and others to be connected with the opening and closing of the valves, or with their attachment to, or movements upon the peduncle. First of all, the adductors or occlusors consist of two muscles, which, bifurcating near the centre of the shell cavity, produce a large quadruple impression on the internal surface of the small valve, and a single divided one towards the centre of the large or ventral valve. The function of this pair of muscles is the closing of the valves. Gratiolet, who has likewise described with great minuteness the muscles of the Brachiopoda, informs us that those which close and open the valves were the only ones known to Pallas, but that he clearly defined their positions and functions. The same was done by Blainville and Quenstedt, but the absence of good figures caused much uncertainty to prevail. This deficiency was subsequently supplied by Hancock's and Gratiolet's admirable illustrations.[1] Two other pairs have been termed *divaricators* by Hancock or *cardinal muscles* (= muscles diducteurs of Gratiolet), and have for function the opening of the valves. The divaricators proper are stated by Hancock to arise from the ventral valve, one on each side, a little in advance of, and close to the adductors, and, after rapidly diminishing in size, become attached to the cardinal process, a space or prominence between the sockets in the dorsal valve. The *accessory divaricators* are, according to the same authority, a pair of small muscles which have their ends attached to the ventral valve, one on each side of the median line, a little behind the united basis of the adductors and again to the extreme point of the cardinal process. Two pairs of muscles, apparently connected with the peduncle and its limited movements, have been minutely described by Hancock as having one of their extremities attached to this organ. The *dorsal adjustors* are attached to the ventral surface of the peduncle, and are again inserted into the hinge-plate in the smaller valve. The *ventral adjustors* are considered to pass from the inner extremity of the peduncle, and to become attached by one pair of their extremities to the ventral valve, one on each side of, and a little behind, the expanded base of the divaricators. The function of these muscles, according to the same authority, is not only that of erecting the shell, but also that of attaching the peduncle to the shell, and thus to effect the steadying of it upon the peduncle.

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[1] Unfortunately almost every anatomist who has written on the muscles of the Brachiopoda has proposed different names for each muscle; hence much confusion has arisen which can but be regretted.

Gratiolet describes the peduncle with great care, and states that it is composed of two portions:—1. A horny sheath formed of concentric epidermic layers, very analogous to that which Prof. Vogt described in *Lingula*. 2. A fibrous stem enveloped by the sheath. This stem, formed of tendinous fibres, is fixed by its free extremity to different marine objects; the other end passes through the foramen into the shell, and ends in a bulbous-shaped extremity.

Such is the general arrangement of the shell muscles in the division composing the articulate Brachiopoda, making allowance for certain unimportant modifications observable in the shells composing the different families and genera thereof.

In the *Tretenterata*, of which *Lingula* may be cited as an example, the myology is much more complicated, and anatomists have differed considerably in their respective views concerning the function of some of the muscles. They have been described by Vogt, Hancock, Gratiolet, and others, and more recently by King, whose views I shall adopt, as they seem to carry with them a greater degree of plausibility[1] (Pl. X. Figs. 1, 2). Of the shell or valvular muscles he makes out five pairs and an odd one, and individualises their respective functions as follows. Three pairs are *laterals*, having their members limited to the sides of the shell: one pair are *transmedians*, each member passing across the middle to the reverse side of the shell: while the odd muscle occupies the umbonal cavity. The central and *umbonal muscles* effect the direct opening and closing of the shell; the *laterals* enable the valves to move forward and backward on each other: and the *transmedians* allow the similar extremities (the rostral) of the valves to turn from each other, to the right or the left, on an axis subcentrically situated, that is, in the medio-transverse region of the dorsal valve. It was long a matter in discussion whether the animal could displace its valves sideways when about to open its shell; but this point has been set at rest by Professors Semper and Morse, who observed the animal perform the operation. They mention that it is never done suddenly, or by jerks: as the valves are at first always pushed to one side several times, and back again on each other, at the same time opening gradually in the transverse direction, till they rest opposite to one another and widely apart. Those who had not seen the animal in life, or who did not believe in the possibility of the valves crossing each other with a slight obliquity, would not consent to appropriating any of its muscles to that purpose, and consequently attributed to all the lateral muscles the simple function of keeping the valves in an opposite position, or holding them adjusted. We have not only the observations of Semper and Morse, but the anatomical investigations of King to confirm the sliding action or lateral divarication of the valves of *Lingula*.

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[1] Journal de Conchyliologie, Octobre, 1857.

In the *Clistenterata*, where no such sliding action of the valves was necessary, or possible, no muscles for such an object were required: consequently none took rise from the lateral portions of the valves, as in *Lingula*. In an extinct group, however, the *Trimerellidæ*, which seems to be somewhat intermediate in character between the *Tretenterata* and *Clistenterata*, certain scars have been found which appear to have been produced by rudimentary lateral muscles; but it is doubtful (considering the shells are furnished with teeth, though but rudely developed) that such muscles enabled the valves, as in *Lingula*, to move forward and backwards upon each other. There are muscles connected with other portions of the animal, such as the *parietal* so strongly defined in the *Tretenterata*, and distinctive peculiarities of the peduncle, etc.; but the limited space at my disposal will not admit of more than a passing allusion to them.[2]

Ranges of Depth.—All Brachiopoda are inhabitants of the sea. A vast amount of important and accurate information has been collected during the past ten years with respect to the geographical distribution of the recent species, as well as to the marine depths they inhabit or prefer.[1]

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[1] King, Annals and Mag. of Nat. Hist., 4th series, vol. xii., 1873.

[2] Davidson and King, on the *Trimerellidæ*, Quarterly Journal of the Geological Society, 1874, vol. xxx. p. 124.

This important knowledge is mainly due to the numerous well-conducted and equipped dredging expeditions carried on by private individuals, and by the Governments of the leading maritime States.

Previous to these investigations the data we possessed with respect to the habitat, and ranges of depth were, in most cases, vague and unsatisfactory. It has also been ascertained that the Brachiopoda are much localised, and usually occur in great numbers in their favourite haunts.

We can know nothing with certainty in respect to the ranges of depth at which the extinct species lived; but some idea as to their probable depths can be surmised from a study of recent forms.

As far as our present information will carry us, the *Tretenterata* (*Lingula*, etc.) do not appear to have been found at a greater depth than from 1366 to 2000 fathoms.

Lingula abounds in particular haunts, and lives at about half tide-mark, and partly buried in mud: or at depths varying from three or four inches from the surface of the sea to seventeen fathoms. Prof. Morse describes a species which he found in vast numbers in a sand-shoal at low-water: the peduncle, six times the length of the shell, was partly encased in a sand tube (Pl. X. Fig. 5). He observed likewise that this species (*Lingula pyramidata*) had the power of moving over the sand by the sliding motion of the two valves, using at the same time the fringes of setæ, which swing promptly back and forth like a galley of oars, leaving a peculiar tract in the sand. In the motion of the setæ he noticed the impulse commencing from behind, and running forward.

Discina has been found attached to stones at low-water mark, and has been dredged from depths ranging from five to nearly 2000 fathoms; very often clustered together in vast numbers, and adhering, in all stages of growth, by their peduncle to the surface of the shell of their neighbour, one above the other, till they formed a living mass of considerable breadth and thickness.

Crania is found in great numbers adhering to stones and shells at depths of from eighteen to 530 fathoms. Lucas Barrett informs us that the cirri are protruded, but not the brachial appendages, beyond the margin of the shell, and that the valve opens by moving upon the straight side of the hinge without sliding the valve.

The genera and species of *Clistenterata* lived at depths ranging from about half tide-mark to 2600 fathoms. At that great depth, between Kerguelen Island and Melbourne, the "Challenger" Expedition brought up, among other things, "a very elegant little Brachiopod;" another species was dredged by the same expedition three hundred miles east of St. Paul's Rocks, Atlantic, at a depth of 1850 fathoms, but the larger number of species live at depths of from five to three, or four hundred fathoms, usually attached by their peduncle to various marine objects, and very often to the outer surface of one another's valves, and even quite young individuals to the peduncle of the parent shell, as may be seen in a number of specimens of *Terebratulina septentrionalis* sent me from America by Prof. Verrill. I have likewise clusters of *Terebratella rubicunda* from New Zealand, adhering to each other in a similar manner. They occur also in great numbers attached by a shorter or longer peduncle to coral reefs, and several minute species were found by Dr. Gwyn Jeffreys fixed to sea-weeds. *Kraussina rubra*, from the coast of Natal in South Africa, was described by Dr. Gray as found attached in vast numbers to *Ascidia* and stems of sea-weeds. We may likewise mention that a small species of *Kraussina* has been recently obtained by Mr. Vélain (during the French expedition to make observations relative to the transit of Venus) in the interior of the breached and submerged crater-basin of the Island of St. Paul, attached, in vast numbers, to rocks at low tide-mark,[1] and I am informed by Dr. Gwyn Jeffreys that *Terebratulina caput-serpentis* was found by the late Mr. R. T. Loweliviry, nearly forty years ago, in the living state, attached to a rock at low-water mark, on a part of the Scottish coast where the tide falls only a few feet. The same species occurs also at variable depths, having been dredged alive from depths varying from three to upwards of 150 fathoms. *Waldheimia cranium* has been obtained from depths varying from 160 to 228 fathoms. Dr. Gwyn Jeffreys does not believe that the habitat of any invertebrate animal is affected by bathymetrical conditions. The late Prof. J. Beete Jukes collected any number of *Waldheimia flavescens* or *australis* while boating in Australia among the reefs; they were merely washed by the tide, and he gathered them with his hand like limpets on the shore.

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[1] The reader is referred to an important paper upon this subject by Prof. Edward Suess, über die Wohnsitze der Brachiopoden (Aus dem xxxvii. und xxxix. Bande, Wien, 1859, 1860, Akademie der Wissenschaften besonders abgedruckt).

Lucas Barrett informs us that this species, as well as *Terebratulina caput-serpentis*, manifested a remarkable power and disposition to move on its peduncle, and that the cirri were almost constantly in motion, and he often observed them to convey small particles to the channel at their base. Dr. J. Gwyn Jeffreys, who has watched *Terebratulæ* alive, informs us that they were incessantly opening and folding their brachial or labial appendages, and drawing and sucking in by means of the whirlpool thus caused every animalcule within their influence.

Classification.—Having briefly alluded to some of the most important characters of the shell and animal of the Brachiopod, it is necessary to refer to their classification. This matter will be found fully discussed up to the year 1853 in the general introduction to my monograph on "British Fossil Brachiopoda."[1] I then published my views, which were subsequently very generally adopted both by British and foreign palæontologists; but I did not omit to impress upon my readers that we were not then (neither are we now) in a condition to prepare a complete or satisfactory classification of the numerous species composing the class. In 1853 I divided the Brachiopoda into eight families comprising twenty-four genera and twenty-two sub-genera; but, during the years that have elapsed since that date to the present time, about seventy more genera or sub-genera have been described. I published a list of them in the *Sussex Daily News* for the 20th of August, 1872, and they will be found recorded in the table accompanying this memoir, where their geological distribution in time has been tabulated, as far as the present state of our information will permit. It it, however, very probable that a certain number of the names there recorded will have to be placed amongst the synonyms, and it is of the utmost importance that genera should not be founded on trifling modifications, or unimportant details which exist only in some abnormal forms. In 1855,[2] I proposed certain modifications in the arrangement published in 1853 by getting rid of the sub-families. Much consideration on my part has been devoted to the subject; but I feel that in order to place the known genera and species in their respective families, or into new ones that will have to be created, much more information must be acquired. The subject is immense when one has to grapple with between 5000 and 6000 described species, varieties or synonyms; and it must likewise be remembered that many of the extinct genera have as yet been but imperfectly elaborated. The material in hand is, however, so great that doubtless, in time, palæontologists will be able to lay before the public a complete history of a class, which, as will be shortly shown, has played an important part in the great life-system of our globe, from its dawn to the present time. It will be necessary, I think, as has already been stated, to admit the two great divisions, *Tretenterata* and *Clistenterata*, into any scheme of classification, although it is impossible to say whether all the extinct genera were provided with an anal aperture, or otherwise.

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[1] Mr. Vélain informs me, that the Brachiopods he forwarded to me (a species of *Kraussina*) are found in great abundance on the shore, in the interior crater of the island of St. Paul. During the ordinary low tides they are scarcely covered by water, and are alternately covered and left bare at the ebb and flow of the tide, but twice a month, during the high tides, they are left completely dry. They occur only in an area of a few yards, and consequently at a very shallow depth, doubtless because they find there those undisturbed conditions to which they are accustomed in other localities.

The TRETENTERATA would comprise the families *Lingulidæ*, *Discinidæ*, *Craniadæ*, and perhaps one or two others.

The CLISTENTERATA would include the families *Terebratulidæ*, *Thecidædæ*, *Spiriferidæ*, *Rhynchonellidæ*, *Pentameridæ*, *Orthidæ*, *Strophomenidæ*, *Productidæ*, and perhaps two or three others that will have to be characterized. By far the larger number of described genera and species would find their places in this last great division and the above-named families. We will now, very briefly, notice some of the characters of the families above indicated.

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[1] A French revised translation of my general introduction by MM. Deslongchamps, father and son, will be found published in vol. x. of the Mémoires de la Société Linnéenne de Normandie, 1856.—A German translation by Prof. E. Suess and Count Marschall was also published in Vienna in the same year, 1856.

[2] Annals and Mag. of Nat. Hist. 2nd ser. vol. xvi.

TRETENTERATA, King.

Family 1. *Lingulidæ.*—Shells generally either oblong or circular, with a peduncle, sometimes of considerable length, passing out between the valves or through a narrow channel in the hinge-margin; texture horny and calcareous: no calcified support for the labial appendages, the fleshy spiral coils directed upwards. This family would comprise the following genera: *Lingula. Lingulella, Lingulops, Lingulepis, Glottidia, Monobolina, Obolus, Obolella, Dignomia, Schmidtia, Acrites, Volborthia,* and some others. It may, however, be hereafter desirable to group the genera above recorded into two groups or families, *Lingulidæ* and *Obolidæ*. *Lingulella* is one of the oldest, if not the oldest type of animal life now known, while *Lingula* appeared for the first time about the middle of the Cambrian period, and has continued to be represented up to the present time.

Family 2. *Discinidæ.*—Shells more or less circular or oval-shaped, attached by a peduncle passing through a foramen in the ventral valve; shell calcareous and horny, setæ extremely long, barbed with cilia of great length: labial appendages fleshy, curved backwards, with small terminal spire directed downwards, as in *Crania*. Genera: *Discina, Trematеs, Discinisca, Kutorgina* (?), *Acrotreta* (?), *Siphonotreta* (?). *Discina* appeared about the middle of the Cambrian period, and has continued to exist up to the present time.

Family 3. *Craniadæ.*—Shells orbicular or limpet-like, entirely free or attached by a greater or lesser extent of the under surface of their ventral valve: labial appendages spirally coiled, directed towards the bottom of the dorsal valve: shell calcareous, perforated by minute canals. Genera: *Crania, Craniops, Craniscus, Pholidops.* The genus *Crania* appeared for the first time during the Silurian period, and has continued to be represented up to the present time.

Family 4. *Trimerellidæ.* — Shells transversely or longitudinally oval: ventral valve usually the largest and flattest, with a more or less developed beak and area: ventral valves generally the most convex, hinge rudely or faintly dentated: all the genera are provided with a solid or vaulted muscular platform in the interior of both valves; no calcareous support for the labial appendages: shell calcareous, and in two of the genera very massive. All the forms are extinct. Genera: *Trimerella, Monomerella, Dinobolus.* The genera and species of this family are restricted to the Silurian period.

CLISTENTERATA, King.

Family 5. *Terebratulidæ.*—Shells very variable in shape, with a prominent beak, truncated by a circular foramen, partly completed by a deltidium in one or two pieces; labial appendages united to each other by a membrane, variously folded upon themselves, and in some genera spiral at their extremities. These appendages are entirely or partially supported by a calcified process assuming a great variety of shapes. All the species lived attached to submarine bodies by the means of a peduncle. Shell structure perforated by canals. Genera: *Terebratula, Terebratulina, Waldheimia, Terebratella,* *Megerlia, Kraussina, Terebrirostra, Magas, Mannia, Bouchardia, Platidia, Argiope, Cistella, Zellania, Reusselaria, Gwynia, Macandrevia Diclasma, Megantheris, Stringocephalus, Trepidolopsis* and some others. *Terebratula* appeared at the close of the Silurian period, and continued to be represented up to the present time; but the larger number of genera have had a very limited distribution in time.

Family 6. *Thecidædæ.* — Shells small, thick, varied in shape, attached by a larger or smaller portion of the shell substance of their ventral valve; area flat; deltidium indistinct; valves articulated; loop in the dorsal valve folded into two or more lobes lying in hollows of corresponding shape excavated in the substance of the valve. This loop, or apophysary ridge, supports the brachial membrane, whose thickened and cirrated margin is apparently attached to the inner sides of the grooves; shell structure perforated by canals. Only one genus at present known, *Thecidium.* It appeared in the Trias, and has continued to be represented up to the present time.

Family 7. *Spiriferidæ.*—Shells variable in shape, ovate, elongated, transverse, trilobate, etc., with the hinge-line straight and extended into wing-shaped expansions: valves articulated, with or without a flattened area in the ventral valve: animal free, or attached during at least a portion of its existence by means of a peduncle, or by muscular fibres issuing from an angular or circular foramen in the beak or area of the ventral valve. Dorsal valve internally furnished with two calcareous spiral processes connected in different manners and directed outwards towards the side of the shell; these processes afforded support to the brachial appendages. This family comprises the following impunctate and punctate genera: *Spirifera, Cyrtia,* greater or lesser length, which coalesce into one median plate, and then diverge to form the dental plates, inclosing a triangular trough-like chamber. In the interior of the dorsal valve are two longitudinal septa of variable dimensions, to which the socket-walls converge, and to which they are joined, forming two more or less developed and inclined plates, to the produced extremities of which were no doubt affixed the fleshy spiral labial appendages. Shell structure impunctate. Genera: *Pentamerus*, *Pentamerella*, and perhaps one or two others.

Family 10. *Strophomenidæ.* — Shells semicircular, transverse, or elongated: valves usually concavo-convex, regularly arched, geniculated or depressed, so that the valve, which is convex in some species, is concave in others, and *vice versâ;* hinge-line long, straight: area in ventral valve flat, with a fissure partly arched over by a pseudo-deltidium. Valves sometimes uniformly convex, the dorsal one sometimes depressed with an area divided by a triangular foramen. In the interior of the dorsal valve a small simple projecting cardinal process is situated between prominent socket-walls, to the inner extremities of which were (probably) attached the brachial appendages. Genera: *Strophomena Streptorhynchus*, *Strophodonta*, *Leptæna*, *Orthis*, *Orthesina*, *Skenidium*, *Brachyprion*, *Discœlosia*, *Meekella*, *Davidsonia* (?), and several others. The first species appeared during the Silurian period, and the last in the Upper Lias. It may, however, be necessary to group the genera provisionally placed in *Strophomenidæ* into one or two families or sub-families. A great family *Orthidæ* might be established. *Strophomena* differs from *Orthis* in having a closed fissure, and the cardinal process bifid or trilobed, while in *Orthis* it is generally formed of one piece. In *Strophomena* it is situated directly between the dental sockets, or has between them and it a small prominent ridge, or brachial process; for this last is scarcely developed, where it exists, and forms a marked contrast to what we find in same valve of *Orthis*. There are also four more or less distinctly defined adductor depressions, which are longitudinally parallel to each other, and separated by ridges, while in *Orthis* these four divisions are placed in pairs one above the other.

Family 11. *Productidæ.* — Shells more or less concavo-convex, oval, semi-oval, or angular, and generally auriculated; the hinge-line straight, with or without teeth and sockets for the articulation of the valves. Surface of ventral valve or hinge-line more or less furnished with tubular spines, sometimes of considerable length: no calcareous process for the support of the brachial appendages: shell structure perforated by canals: cardinal process prominent, trilobed or bilobed. Under this a narrow longitudinal ridge generally extends to about half (or more) of the length of the valve, and on each side are seen the ramified dendritic impressions, which may be attributable to the adductor muscle. Outside, and in front of these are the two reniform impressions so characteristic of the family. Genera: *Productus*, *Strophalosia*, *Aulosteges*, *Chonetes*, *Productella*. The *Productidæ* made their first appearance during the Silurian time, and became extinct at the close of the Palæozoic period.

(*To be concluded in our next Number.*)

(Plates VII. and VIII. accompanied Part I. of Mr. Davidson's memoir.)

FIG. CLISTENTERATA. PLATE IX.

1. *Waldheimia flavescens.* Interior of ventral valve. *f.* foramen; *d.* deltidium; *t.* teeth; *a.* adductor muscular impressions (= occlusor *Hancock*) *close valves; c.* divaricator *Hancock* (= cardinal muscles *King* = muscles diducteur principaux, *Gratiolet*) *open valves*; *c′.* accessory divaricators *Hancock* (= muscles diducteurs accessoires *Gratiolet*); *b.* ventral adjustors *Hancock* (= ventral peduncular muscles or muscles du pedoncule paire superieur, *Gratiolet*); *b′.* peduncular muscle *Hancock.*
2. ——— Interior of dorsal valve. *c, c′.* Cardinal process; *h′.* hinge-plate; *s.* dental sockets; *l.* loop; *a.* adductor (=anterior occlusor *Hancock*; valvular muscles *King; a.* adductor (= posterior occlusor *Hancock*); *c′.* accessory divaricator, point of attachment (= muscles diducteurs accessoires Gratiolet; *b″.* dorsal adjustor, points of attachment (= dorsal peduncle muscle = muscles du pedoncule, paire inferieur *Gratiolet.*
3. ——— Diagram showing the muscular system after Hancock. M. ventral valve; N. dorsal valve; *l.* loop; *v.* mouth; *s.* extremity of intestine; *a.* adductor; *c.* divaricators; *c′.* accessory divaricators; *b.* ventral adjustors; *b′.* peduncular muscle; *b″.* dorsal adjustors; P. peduncle.
4. ——— Interior of dorsal valve to show the position of the labial or brachial appendages; a portion of the fringe of the cirri has been removed to show the brachial membrane and a portion of the spiral extremities of brachial appendages.
5. ——— Longitudinal section of valves, with a portion of the animal. *d, h.* labial appendages; *a.* adductor; *c′, c′.* divaricator muscles; D. cardinal process; *s, s.* septum; V. mouth. The adjustor or peduncular muscles have been purposely omitted.
6. *Waldheimia flavescens.* Portion of the labial appendages, enlarged, showing the interbranchial membrane. *w.* the canal; *y, q.* ciliated cirri coated with spiculæ (after E. Deslongchamps).
7. *Rhynchonella psittacea.* Interior of dorsal valve. *a.* adductor muscular impressions; *l.* short curved lamellæ for support of labial appendages.
8. ——— Showing the spirally rolled labial appendages (after Owen's original figure, Trans. Zool. Soc. vol. i. pl. 22, fig. 14); but I have given a more correct illustration of the position of the brachial appendages, of *R. nigricans*, in the Memoirs of the Soc. Linnéenne de Normandie, pl. x fig. 11, 1857.
9. *Terebratella Magellanica.* Interior of dorsal valves, to show the double attachment of the loop.
10. *Platidia anomioides.* Interior of dorsal valve, to show the position and shape of the brachial appendages.

TRETENTERATA. PLATE X.

1. *Lingula anatina.* Interior of ventral valve (diagram after King).
2. ——— Interior of dorsal valve. *g.* umbonal muscular impressions (*open valves*); *h.* central muscles (*close valves*); *i.* transmedial or sliding muscles; *b.* parietal band; *j, k, l.* lateral muscles (*j.* anteriors, *k.* middles, *l.* outsides), enable the valves to move forward and backward on each other.
3. ——— Diagram of the muscular system (after Hancock). The letters indicate the same muscles as are designated in King's figures 1 and 2; *p.* peduncle; *e.* heart; *a.* alimentary tube; *z.* anal aperture.
4. ——— enlarged (after Hancock), to show the dorsal pallial lobe or mantle turned back to expose the pallial chamber; *c.* marginal fold; *v.* pallial sinuses; *o.* spirally coiled brachial apparatus; *c″.* liver; *l.* lateral muscles; *k.* lateral muscles (middles); *i.* transmedial or sliding muscles; *x.* lateral wall of body; *z.* anal nipple.
5. *Lingula pyramidata* (after Morse). Showing manner in which the valves slide their valves, also portion of the long peduncle, to which sand has agglutinated in the shape of a tube.
6. Embryos removed from the pallial sinus of *Lingula anatina*, magnified 120 diameters, (after Owen).

III.—On Certain Genera of Living Fishes and their Fossil Affinities.[1]

By Miss Agnes Crane.

ON first thoughts, it may seem that the lowest group of vertebrates, of all the divisions comprised in the animal kingdom, might be most easily described, and its zoological limits defined; but, on examination, the fishes prove to be most curiously linked to the invertebrata below and the amphibian reptiles above. In fact, it is not easy to draw the lines positively between them, and to say where the true vertebrates begin, or where the piscine characters are merged in the reptilian. It is proposed to refer to some of the most aberrant forms of living fish and their fossil affinities; then, briefly passing in review the distribution of the various families in geological time, to see how far descent with modification is traceable in this class of vertebrates.

The Lowest Vertebrate.—It is well known that the lowest vertebrate form is the anomalous lancelet (*Amphioxus lanceolatus*), which is found burrowing in sand banks on our southern shores and in the Mediterranean. The position which this singular species should occupy in the animal kingdom has long been a subject of debate among naturalists. Some, like Agassiz, separate it entirely from all other fishes, while Haeckel proposes to place it in a distinct division of the Vertebrata, and Professor Semper removes it from the vertebrates altogether. But Professors Owen[2] and Huxley,[3] considering it to possess the rudiments of a skull and brain, with the elements of a vertebral column, retain it among the fishes, and it forms the first or lowest order of their respective systematic arrangements. In *Amphioxus*, which ranges from one and a half to two inches in length, the vertebral column is notochordal throughout life, that is to say, composed of a membraneous rod inclosed in cartilage; and as there is no enlargement of the skull for the reception of the brain, the animal tapers nearly equally at either end. The skin is scaleless, lubricous, and so transparent that the internal structure is visible, and the eyes are not more fully developed than in the common leech. The mouth is vertical, jawless, and suctorial, and is furnished with vibratile cilia. The lancelet possesses neither heart nor swimming bladder, and is without ribs and even rudimentary limbs. In all other fishes respiration is effected by means of water passing through the mouth and escaping by the gills, or their equivalents; in this species t traverses the whole interior of the animal and escapes by a special pore on the under surface of the body. Professor Goodsir[4] long ago called attention to this peculiar mode of respiration, and noticed the resemblance between the enlarged phrangeal sac of Amphioxus and that of the tunicated mollusks or sea squirts. He considered the lancelet also as allied to the annulosa, from the simple organization of its respiratory and circulatory system, and M. Kowalevsky has more recently traced a close affinity between this species and the early stages of some Ascidians. Thus, in *Amphioxus* are united characters belonging to the Tunicates and Annelides, and unexpected relations are revealed between the *Vertebrata* and the *Invertebrata*.

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[1] Read before the Brighton Nat. Hist. Soc. Feb. 8th, 1877, and the Geologists' Association April 6th, 1877.

The writer is much indebted to Dr. Günther, F.R.S., and Mr. W. Davies, F.G.S., f the British Museum, for information kindly imparted, and facilities and assistance fforded in the examination of specimens.

[2] Anatomy of Vertebrates, vol. i.

[3] Preliminary Note on the Structure of the Skull and Brain in *Amphioxus lanceolatus*, Proceedings of the Royal Society, 1874, No. 157, December.

[4] Transactions of the Royal Society of Edinburgh, vol. xv. pl. 11, p. 259.

THE MOST HIGHLY ORGANIZED FISH.—In the *Lepidosiren*, the highest of all the fishes, we find an organization of a no less complex nature. The genus was founded in 1837 by Dr. Natterer for the reception of a singular animal to which he gave the specific name of *paradoxa*, discovered by him in America, inhabiting the swamps in the vicinity of the river Amazon. This species, which attains a length of three feet, the body being eleven times as long as the head,[1] is now becoming very rare. In 1839 Prof. Owen referred specimens from the river Gambia of West Africa to the same genus, under the designation of *Lepidosiren annectens*, and classed them in a provisional group between the reptiles and fishes. They are placed by Prof. Huxley in the highest order of his classification of fishes, namely, the *Dipnoi* or "double breathers," and are popularly known as "mud-fish." These paradoxical "scaled sirens" have well-developed reptilian lungs co-existing with functional internal branchiæ, and are capable of living either in the water or out of it. Their structure and habits are very peculiar. During the rainy season, the waters of the Gambia overflow its banks, and the mud-fish is carried out of the true bed of the river. When the waters retire it is left stranded; then, burrowing in the softened mud, it coils itself up, keeps open a communication with the air above its nest, and breathes by means of its modified swimming bladder. It thus remains inactive till the return of the floods soften the walls of its cell, when it emerges, and resumes its former habits. They have been found in a semi-torpid state eighteen inches below the surface, in situations where the ground is dry and hard for months in the year, and are dug out by the natives with a sharp pointed stick and used for food.[2] The body of the *Lepidosiren* is fish-like, and covered with small cycloid scales, simply constructed pectoral and ventral limbs are present, with a dorso-caudal fin. The notochord is persistent, but the skull is partly bony, partly cartilaginous, and the costal arches and neural and hæmal spines are well ossified; thus it forms a link between the bony and cartilaginous types of fishes. The dentition s composed of a pair of vomerine teeth, and two molars in each aw. The heart is three-chambered, and true lungs exist with udimentary external branchiæ and functional internal ones.

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[1] Trans. of the Linnæan Society, vol. xviii.

[2] A specimen of *L. annectens* has been on exhibition in the entrance hall of the Brighton Aquarium for more than two years. It is kept at a regular temperature of 70°, and is in a very thriving condition, having grown several inches since it has been in the institution, and thickened proportionately. The animal generally lies quietly at the bottom of its tank, rising occasionally to the surface to take in air. It is fed three times weekly on small pieces of raw beef, which it can be observed to eat in a very unusual manner. When the food is thrown in, the mud-fish stretches itself leisurely and seizes it, as it comes within reach, between its sharply formed vomerine teeth. After masticating it slowly, it throws it out with a quick jerk, and, commencing at the other end, repeats the manœuvre; it then again rejects it, and subjects it to a third process of mastication before finally swallowing it.

LIVING AFFINITIES OF LEPIDOSIREN.—Among living fish, the *Lepi*-*osiren* is most closely related to another "dipnoid," discovered in the vers of Queensland, Australia, in 1870. This species was at once, ith singular accuracy, referred by Mr. Gerard Krefft, the late Curator the Sydney Museum, to *Ceratodus*, a genus till then only known by e fossil teeth which occur abundantly in Triassic, and rarely in olitic strata.[1] He also described it "as a gigantic amphibian, and as lied to *Lepidosiren*," the correctness of which determination has en fully demonstrated by the subsequent minute investigations of r. Günther[2] and Prof. Huxley,[3] who have published exhaustive emoirs on this subject. Two species of living Ceratodonts are cognized, one named after its discoverer, the Hon. William Foster, *ratodus Fosteri*, and *Ceratodus miolepis*, distinguishable only by its aller and less ornate scales. These fish, known locally as "flat-ads," inhabit the fresh and brackish waters of the Queensland vers, and "at night leave the streams, and go out on the flats, nong the reeds and rushes, subject to tidal influence." Dr. ünther is, however, of opinion that they do not probably live ely on land, as the limbs are too flexible and feeble to support the avy body, and considers that though they may be occasionally mpelled to leave the water, they could not remain long in a lively ndition without it. The species, which range up to six feet in ngth and twenty pounds in weight, appear to feed exclusively on e remains of plants *Myrtacæ* and *Graminæ*, taken in a decomposing ate. The body of *Ceratodus* is covered with large cycloid scales, d the limbs are structurally identical with those of *Lepidosiren*, t the axis and fringe are more dilated, and the fin scales distinctly sible. The internal skeleton, though of a more cartilaginous type, sembles that of the mud-fishes, and the skull is partly osseous. e anterior nasal openings are situated under the lip, in front of e vomerine teeth, while the posterior pair are placed in the cavity the mouth, a little before the maxillary ones. The dentition is sentially that of *Lepidosiren*, slightly modified to suit herbivorous et, being adapted rather for "cutting and crushing" instead of piercing and cutting." It consists of a pair of vomerine teeth, d two molars in each jaw, thus proving the correctness of the ews of Pander and Agassiz, who had assigned that number of ntal plates to the fossil forms of the middle geologic ages. The spiratory organs are twofold, as in *Lepidosiren*, but the gills are ore developed in *Ceratodus*, and when inhabiting clear waters the h probably breathes by them alone, the true lungs only coming to action when on the mud flats, or living in turbid waters. The ape of the body, the number, position, and structure of the fins, the elements of the internal skeleton, and above all the co-existence of a lung with gills, show how close is the affinity between the Australian *Ceratodus* and the mud-fishes of Africa and South America, and although the former approach less to the amphibian type than the latter, it is obvious that in a natural classification their place is side by side.

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[1] *Ceratodus Phillipsi*, Ag., Great Oolite, Mantell Coll., British Museum.

[2] Transactions of the Royal Society, 1871.

[3] Proceedings Zoological Society, *1876, part* i. June.

FOSSIL AFFINITIES OF THE DIPNOI.—Having shown the clos connexion between the two genera of living dipnoids, let u now consider the relations of the living and fossil Ceratodonts. No remains of this genus have as yet been found in the Tertiary or Cretaceous formations; but the fossil teeth, of which several varieties are recognizable, possibly the relics of numerous species, occur abundantly in the Triassic beds of Aust Cliff, near Bristol, and in the Muschelkalk of Germany. They have also been obtained from strata now determined to be of Triassic age a Maledi, south of Nagpur, in India, and associated, as in Europe with the reptilian remains *Hyperodapedon*. Many of these fossil teeth are much larger than those of the existing species (specimen of one Triassic form measure over two inches in length), and mus necessarily have belonged to individuals of a gigantic race. Th dental plates only have been found fossil, but the structure o *Ceratodus Fosteri* indicates that they alone of a like-constructe animal would be susceptible of preservation in sedimentary strata, and the classification of the recent forms with those of the Mesozoi rocks, separated by so wide a gulf of geological time, thoug founded on the similarity of the dentition alone, is the only reasonable one, as there is no evidence that the living and fossil Ceratodonts, differed from each other. The teeth of this genus resembl in general shape and structure those of *Ctenodus* which are widel distributed in Carboniferous strata, species occurring in Americ being identical with those of the British rocks of contemporaneou age. The dentition of the Devonian *Dipterus* is also closely relate to that of *Ceratodus*, as well as *Lepidosiren*.[1]

Thus the history of the *Dipnoi*, an order before the discovery o the Australian *Ceratodus* only represented by the mud-fishes of Afric and South America, is carried back to remote geological ages, an the four living representatives, at present known, are found to b the survivors of a well-defined and characteristic group of fishes fir appearing in the Devonian age. They can be traced up from *Dipterus*, through the Carboniferous *Ctenodus*, to the Jurassic Cerato donts, and then the link is lost sight of until their lineal descendants reappear widely distributed on the surface of the present world. This is but an illustration of the truth that species which have the greatest vertical range in time have also the widest geographical distribution, or that a wide distribution proves the antiquity of the genus. It is certainly a very significant fact that the group of living fish most closely allied to the amphibian reptiles should be represented in the Devonian rocks, long before the most simply constructed amphibians appeared on the scene of life in the swamps of the Carboniferous period. The *Dipnoi*, as at present constituted, includes the following families: *Protopterina*, *Ceratodontina*, *Ctenododipteridæ*, and possibly *Phaneropleuridæ*. They are closely allied to the Ganoids, and especially to that sub-order termed, by Prof. Huxley, the *Crossopterygidæ*, or "fringe-finned," to be presently referred to. Dr. Günther, indeed, proposes to unite the dipnoids with the ganoids, as a distinct family; but Prof. Huxley considers that, though nearly related to that order, they yet possess many important differences. It seems as if the *Dipnoi* had also some affinities with the group of fishes known as *Placoderms*, for a most remarkable fossil fish has recently been discovered in America, the dentition of which is almost exactly like that of *Lepidosiren*, except that it is about one hundred times greater. The genus *Dinichthys* was founded by Prof. Newberry for the reception of this gigantic *Placoderm*, of which two species at least are recognized and graphically described by him, in vol. ii. of the State Reports of the Palæontology of Ohio. They occur in the Huron Shales of the Upper Devonian series, where they seem to have preponderated in number, fragments of over a hundred individuals having been detected, while the remains of other genera are found more rarely in the same horizon. The jaws of this "terrible fish" were each two feet long, the breadth of the head was about three feet, and the cranium was composed of massive bony plates, the solid bone of the occipital portion being three inches in thickness. The length of the body is estimated by Professor Newberry to have been about fifteen feet, and its diameter three. The anterior portion was protected by huge dorsal and ventral shields, resembling, in general shape and structure, those of the genus *Coccosteus*, rendered classic by the pen of Hugh Miller. Very little is known with regard to the fins, "about six inches only of an apparently median fin, with well-ossified rays as thick as one's little finger," having as yet been found, and, from the absence of scales, it is conjectured that the posterior portion of the body of the animal was covered with a tough skin, as in *Coccosteus*, a genus which possibly protected itself, like the modern sheat fish of the Ganges, by burrowing in the mud, watching for prey with only its mail-clad parts exposed. The powerful dentition of *Dinichthys* is suggestive of carnivorous habits, and probably being so heavily weighted by the thick shields encasing its vital organs it would be compelled to obtain food rather by cunning than by swift pursuit. It is worthy of notice that the ponderously armed *Placoderms* had a comparatively short range in time, remains of the group being only found in the Upper Silurian and Devonian rocks; thus it seems as though, unable to cope in the struggle for existence with the lighter-armed and more active race of ganoids which predominated in the Devonian waters, they died out, leaving no immediate descendants. The vertebral column in the *Placoderms* was generally cartilaginous, a condition considered by some authors as indicative of a low organization, but as the quantity of bone composing their external shields was much greater than that forming the internal skeleton of the existing types of true bony fishes, and as traces of ossified caudal vertebræ have been discovered in one genus, they ought rather to be highly placed in a systematic classification. The group is considered by Professor Huxley to form a link between the Ganoids and the Teleosts, and as having most affinity with the living plated Siluroid Teleosts of the African rivers.

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[1] Prof. J. S. Newberry (vol. ii. Palæontology of Ohio, p. 63, pl. 58, fig. 18 recognizes in his new genus *Heliodus*, occurring in the Upper Chemung group of th American Devonian, the most gigantic member of the family of dipterine ganoids t which *Ceratodus*, *Ctenodus*, and *Dipterus* belong. The teeth resemble in microscop structure those of *Dipterus*, and in general shape those of *Ctenodus*. The upp palatal ones differ, however, from those of all other known dipnoids in being unite "in the form of a fully-opened fan." He is also of opinion that the *Paleaph insignis* of Van Beneden and de Koninck, from the Carboniferous strata of Belgiu is not generically identical with the *P. Devoniensis*, of the same authors, and whi admitting that the former is really a Plagiostome, considers that the latter shou be associated with his new dipterine genus under the designation of *Heliod Devoniensis*.

DISTRIBUTION AND RANGE OF THE PISCINE FAMILIES IN GEOLOGICAL TIME.—In considering the distribution and range of the various families in geological time, we find that authenticated remains of sharks, *Placoderms*, and Cephalaspids have been obtained from the Lower Ludlow Beds of the Upper Silurian in Europe, but in America it is singular that no fossil fishes have as yet been discovered before the Devonian epoch, when the relics of numerous genera occur abundantly, differing, however, from the European forms. This dissimilarity in the fauna is probably owing to the differences existing in the physical geography of the two areas at the time of the deposition of the series. The Devonian formation is built up of freshwater, estuarine and marine strata, each group characterised by its peculiar forms of life. In the Old Red Sandstone of Scotland and Russia, freshwater species predominate, while in the marine limestones of Devonshire, and the Eifel, Mollusca, Corals, and the remains of genera of inshore dwelling fish indicate a shallower marine deposit. The greater part of the American Devonian, on the contrary, was apparently laid down in an open sea, and thus a monster marine fauna flourished, not so generally represented in Europe; but it is interesting to note the identity of a few species occurring in localities where the beds are of similar structure to those of contemporaneous age in Europe. In both worlds the formation is alike distinguished by the great preponderance of ganoid over elasmobranchiate fishes. The conditions existing during the formation of the Devonian rocks are well illustrated at the present day by the freshwater lakes, mighty rivers, and extended coast-line of the African and American continents, and it is a most suggestive and significant fact that the genera of living ganoid and dipnoid fishes most resembling the Palæozoic forms are now, with two exceptions, found on those continents alone. Taking the various orders of Professor Huxley's comprehensive classification in succession, we find that no traces of the first or lowest order, the Pharyngobranchii, which contains only the "gullet-breathing" Lancelet, have been found in a fossil state. This is easily accounted for, however, by the soft and perishable structure of the species, of which no remains could possibly be preserved in the finest sedimentary strata, and, therefore, the non-representation of this lowest form of ichthyic life in "the records of the rocks" becomes less remarkable. Of the cartilaginous *Marsipobranchii*, comprising the hag fishes and lampreys, the horny teeth alone would be susceptible of preservation, and their absence has been commented on as negativing the evidence of progressive development among fishes, as it is obvious the most simply constructed forms should appear first on the scene of life in order to give place to their more highly organized descendants. In 1856, Pander, in his magnificent work on the Silurian and Devonian fishes of the Russian Baltic Provinces, gave numerous figures of what he supposed to be the teeth of small sharks from the Lower Silurian rocks, but these so-termed conodonts have not been accepted as of true ichthyic origin. Professor Owen[1] retains only three species as possibly the teeth of fishes, and is of opinion that the remainder might be either the ornaments of crustaceans, "or the spines, or hooklets, or denticles of naked mollusks or annelides." Great numbers of these "cone teeth" have recently been detected in Carboniferous strata, both in England and America, and it is suggested that they may be the teeth of cyclostomous fishes like the hags and lampreys, and thus be the representatives of the *Marsipobranchii* of the ancient Silurian seas. They seem most to resemble in shape and structure the teeth of the *Myxinoids*, in which the dentition is peculiar, being composed of one horny conical tooth situated in the roof of the mouth, with two serrated dental plates on the tongue. It has been objected that the teeth of living cyclostomous fishes are horny or chitonous, while the fossil cone teeth are calcareous, but this applies with equal force to the theory that they are the teeth of mollusks, as the modern shell fish have siliceous teeth. The piscine derivation of the conodonts is, however, still a debated question requiring careful investigation, as it would antedate the appearance of ichthyic life in geologic history; but if it cannot be asserted that they are the teeth of fishes, neither as yet can it be positively proved that they are not.

The next order, the *Elasmobranchii*, embraces the sharks, dog fishes, rays, and *Chimæroids*. The first of these families has enjoyed a long range from the Upper Silurian epoch to the present day, and one genus seems to have varied but slightly, the *Cestracion Phillipi* or Port Jackson shark of Australia being a descendant of the ancient *Cestracionts*, a once numerous family now verging towards extinction. The *Chimæroids* appeared first in the Devonian, and live on, but the Rays were not represented until the Jurassic age. The *Placoderms*, as we have seen, enjoyed but a transient existence, dying out at the close of the Devonian, while the *Teleostei* or true bony fishes which so largely predominate at the present day did not appear on the scene of life until the formation of the Cretaceous rocks. Seven living genera alone survive of the *Ganoidei* which prevailed so numerously in Palæozoic times, and but one of these, the sturgeon, the least characteristic of the group, is found in European waters. Two of the six remaining forms, which are all dwellers in fresh water, occur in Africa, and four inhabit the lakes and rivers of North America. The preservation of the majority of living ganoids in America is probably owing to the fact that some portions of this ancient continent, truly the old world of *geologists*, have never been submerged since their upheaval from the first Silurian seas; thus some representatives of this ancient race of fishes were able to find a refuge in its bays and rivers, and the chai of descent has been kept unbroken from the early ages of th incalculably remote past. The large-spined, shagreen-scaled *Acan thodidæ*, which are considered by Professor Huxley to link th Ganoids to the Elasmobranchs, range only in the Devonian an Carboniferous rocks. The "thick-toothed" *Pycnodonts* lived fron the Coal-measures to the Tertiaries, and are now extinct, while th buckler-headed *Cephalaspidæ*, like the *Placoderms*, existed only i Silurian and Devonian times. The *Chondrosteidæ*, to which grou the sturgeons belong, were certainly represented in the Jurassic sea and possibly by the gigantic *Macropetalichthys* in the Devonia *Amia calva*, the dog fish of the American lakes, is the sole membe of the sub-order *Amiadæ*.[1] The *Lepidosteidæ* includes the livin bony pikes, inhabitants of the rivers of the same continent, and fossi forms in all the formations reaching back to the Devonian.

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[1] *Enc. Brit., vol. xvii., part i.,* 1859, art. Palæontology.

There remains for discussion but the sub-order *Crossopterygidæ* that important group of fringe-finned ganoids, through which Prof Huxley[2] considers the passage from the fishes to the reptiles tool place. All the families of this well-defined sub-order are character ized by the possession of lobate paired fins having a central axis o stem covered with scales like the body walls, and surrounded by fringe of fin rays. Two dorsal fins are present in the majority Jugular plates always replace the branchiostegal rays, and the scale are either rhomboidal or cycloidal. The families *Saurodipterini Glyptodipterini*, and *Phaneropleurini* are restricted to the Palæozoi rocks.[3] The *Cœlacanthini* range from the Carboniferous to th

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[1] Two species, namely, *Amia scutata* and *A. dictyocephala* Cope, are referred t Prof. E. D. Cope (in the Bull. of the United States Geol. and Geog. Survey, No. 2nd series, 1875) to the genus *Amia*. They are recorded as occurring in the Terti Shales of South Park; apparently a freshwater deposit of later Tertiary age.

[2] Decade x. of the Memoirs of the Geological Survey, 1861 (Classification Devonian Fish).

[3] In the memoir on *Tristichopterus alatus*, Eg. (Trans. Roy. Soc. Edinburgh, v 27, 1875), Dr. Traquair follows Dr. Günther in associating the *Ctenodipterini* Huxley (*Ctenodus*, *Dipterus*) with the Dipnoi, but retains the *Phaneropleuridæ* a sixth family of Crossopterygian ganoids, sub-dividing the remaining families th 1. Polypteridæ; 2. Cœlacanthodæ; 3. Rhombodipteridæ, sub-fam. *Glyptolæm* (*Glyptolæmus*, etc.), *Saurodipterini* (*Osteolepis*, *Diplopterus*); 4. Cyclodipteri (*Tristichopterus*, etc.); 5. Holoptychidæ (*Holoptychius*, etc.); 6. Phaneropleuri (*Phaneropleuron*, *Uronemus*). In the memoir on British Carboniferous Ganc by the same author, published in the vol. of the Pal. Soc. for 1877, Palæoniscidæ are raised to the rank of a distinct family, and removed from sub-order LEPIDOSTEOIDÆ into that of the ACIPENSEROIDEI. The DIPNOI retained as a separate *order*, and the following classification is proposed for order GANOIDEI.

Sub-order I. Crossopterygii.
„ II. Acipenseroidei.
Fam. 1. Acipenseridæ.
„ 2. Spatularidæ.
„ 3. Chondrosteidæ.
Fam. 4. Palæoniscidæ.
„ 5. Platysomidæ.
Sub-order III. Lepidosteoidæ.
„ IV. Amioidei.

Chalk, and the *Polypterini*, comprising only the living *Polypterus* and *Calamoichthys* of Africa, alone represent this once prevailing race of fishes at the present day. The genus *Polypterus* is remarkable for the unique arrangement of its sub-divided dorsal fin, and by the possession of a double cellular air bladder, which most nearly approximates to the lungs of the *Dipnoi*. It has least structural affinities with the *Cœlacanths*, its nearest allies in time, and is most closely zoologically related to the rhomboidal scaled *Saurodipterines* of the Devonian, from which it is separated by an enormous gulf of geological time, as no intermediate links have been discovered.

In the notochordal *Phaneropleurini* we find forms which most closely resemble the acutely lobate finned Lepidosiren. The shape of the body, number, position, and structure of the fins, and all the elements of the internal skeleton, exactly foreshadow those of the mud-fishes. Like them Phaneropleuron was covered with thin cycloidal scales, through which the long and well-ossified ribs show so plainly in the fossil state as to suggest the name of the genus. The dentition, however, differs from that of *Ceratodus* and *Lepidosiren*, being composed of a row of short conical teeth in each jaw; and in the absence of the grooved dental plates so characteristic of the true *dipnoi*, it is uncertain whether this family can be associated with the other members of that order. The chain of descent is carried on by the *Cœlacanthini*, the only fringe-finned ganoids occurring in the Mesozoic rocks. They can be traced up from *Cœlacanthus* in the Carboniferous, through *Holophagus* in the Lias and *Undina* in the Oolites, up to *Macropoma* in the Chalk. The family is distinguished by cycloid scales, hollow fin supports, and a notochordal skeleton built on the same principle as that of the mud-fishes. In some genera the walls of the air bladder are ossified. This peculiarity, which was first suspected by Mantell, is especially remarkable in *Undina* and *Macropoma*. No fossil Crossopterygids have been discovered in Tertiary strata, but it is the opinion of Professor Huxley that, as the rhomboidal scaled Saurodipterines of the Devonian rocks are now represented by the living Polypterus, so the stiff-walled lungs of the Lepidosiren are the homologues of the ossified air bladder of the Cœlacanths, and thus that genus carried up the cycloidal branch of the Crossopterygids to the present day.

Such, in the abstract, is the life history of fishes, a class characterized, like other divisions of the animal kingdom, by the extinction of some groups after a brief existence, and by the persistent endurance of others through untold ages. In the few genera of living ganoids we have undoubtedly the surviving descendants of a numerous and powerful race which prevailed in the Devonian epoch, and by the discovery of fossil dipnoal forms the progenitors of *Ceratodus* and *Lepidosiren*, the *Dipnoi* are likewise proved to be of ancient lineage. The greater part of the existing piscine fauna, on the contrary, is shown to be of comparatively modern date. Moreover, in considering the fact that the early fishes are remarkable from a combination of diverse characteristics which subsequently become the distinguishing peculiarities of distinct families, and of a higher order,

TABLE SHOWING THE CLASSIFICATION AND GEOLOGICAL DISTRIBUTION OF FOSSIL FISHES.

ORDERS AND SUB-ORDERS.			FORMATIONS.												
			Palæozoic.					Mesozoic.				Cainozoic.			
OWEN	HUXLEY.	GÜNTHER.	L. S.	U. S.	D.	C.	P.	T.	L.	O.	C.	T.	R.	Generic Fossil Types.	Generic Living Examples.
PROTOPTERI	DIPNOI [1]				?	?	?	?		?			x	*Dipterus? Ctenodus? Ceratodus?*	*Ceratodus*, *Lepidosiren*.
TELEOSTOMI [14]	TELEOSTEI [2]	IV. TELEOSTEI.									x	x	x	*Beryx*, *Osmerus*.	Herring, Carp, Perch, etc.
Placo-Ganoidei	Placodermi [3]	III. PALÆICHTHYES [16]		x	x									*Dinichthys*, *Coccosteus*, *Pterichthys*, *Asterolepis*.	
Lepido-Ganoidei	GANOIDEI [4] Sub-orders,—	Ganoidei, including Dipnoi.													
,, ,,	— *a* Amiadæ											?	x		*Amia calva* the dog-fish of the American lakes.
,, ,,	— *b* Lepidosteidæ [5]				?	?	x	x	x		x	x	x	*Lepidotus*, *Palæoniscus*.* *Cheirolepis*.	*Lepidosteus* Bony Pike of America.
,, ,,	— *c* Crossopterygidæ [6]				x	x	x	x	x	x	x		x	*Osteolepis*, *Glyptolepis*, *Macropoma*.	*Polypterus*, *Calamoichthys* of Africa.
	— *d* Chondrosteidæ				?				x			x	x	*Chondrosteus*.	Sturgeon (*Acipenser*).
Placo-Ganoidei	— *e* Cephalaspidæ [7]			x	x									*Auchenaspis*, *Cephalaspis*, *Pteraspis*.	
	— *f* Pycnodontidæ [8]					x	x	x	x	x	x	x		*Platysomus*, *Pycnodus*, *Cœlodus*,	
Lepido-Ganoidei	— *g* Acanthodidæ [9]			x	x									*Acanthodes*.	
PLAGIOSTOMI [15]	ELASMOBRANCHII [10]	Chondropterygii, [17]													
Plagiostomi	*a* Squalidæ	= Plagiostomi.		x	x	x	x	x	x	x	x	x	x	*Acrodus*, *Ptychodus*.	Sharks, dog fishes, *Cestracion Phillippi*.
	b Raiidæ									x	x	x	x	*Rhinobates*.	Torpedo, skates, etc.
Holocephala	*c* Chimæridæ [11]	Holocephala.			?					x	x	x	x	*Edaphodon*, *Elasmodus*, *Ischyodus*.	*Chimæra monstrosa*,† *Callorhynchus*.
	MARSIPOBRANCHII [12]	II. CYCLOSTOMATA. [18]											x		Hag (*Myxine*) Lampreys (*Petromyzon*).
DERMOPTERI	PHARYNGOBRANCHII [13]	I. LEPTOCARDII. [9]											x		Lancelet (*Amphioxus*).

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1. Double breathers.
2. Perfect boned.
3. Bony plated.
4. Glistening scaled.
5. ...
6. Fringe finned.
7. Buckler headed.
8. Thick toothed.
9. Large spined.
11. Monster headed.
12. Pouched gills.
13. Gullet breathing.
14. Complete mouthed.
15. Oblique mouthed.
16. Ancient fishes.
17. Cartilage finned.
18. Circle mouthed.
19. Slender heart.

* According to Dr. Traquair there is no true *Palæoniscus* in the British Carboniferous rocks.

† King of the herrings.

we find further evidence that the ancient ganoids formed the parent stock from which the succeeding fishes, amphibians, and reptiles have diverged. In some sauroid Devonian fishes the position and structure of the teeth foreshadow those of the Labyrinthodont reptiles, in others the throat is protected by gular plates, a fashion retained in the Carboniferous amphibia. Again, in some species the scales are surface pitted, like the scutes of Crocodiles. While, in the notochordal weak-limbed amphibians of the Coal-measures, with minute body scales, and partly osseous skulls, we cannot fail to recognize structural peculiarities now found in the swamp-dwelling mud-fishes. Thus in the anomalous "scaled sirens," we have the "persistent type" of an ancient group of fishes, in which now, as in the old time, the piscine and amphibian characters are so united as to completely efface the line of demarcation between the orders, and effectually link the fishes to the reptiles.

NOTICES OF MEMOIRS.

Proceedings of the Manchester Literary and Philosophical Society, vol. xvi. No. 10, p. 171. Session 1876–77.—Ordinary Meeting, March 6, 1877.

A PAPER was read by Mr. Arthur Wm. Waters, F.G.S., entitled "Inquiries concerning a Change of Position of the Earth's Axis." The author stated that the cause of the greater warmth in high latitudes during the Tertiary period had not, in the opinion of many, yet received any satisfactory solution.

The Arctic Miocene Flora was considered. 356 Miocene species of plants have already been determined from latitude 70–77 N. in Spitzbergen and Greenland, and include *Taxodium* (swamp cypress of Texas), *Sequoia*, birch, lime, oak, beech, plane, and even magnolia; so that Prof. Heer, by comparison of the localities of these, says that the temperature must have been 30° F. warmer than at present. Fossil floras of the Cretaceous, Jurassic, and Carboniferous periods have been discovered within the arctic circle. Most of these plants are unable to resist severe cold, besides requiring a warm summer, and it seems difficult to accept the fact of their flowering and ripening their seeds, where the winters are so long and the summers so short, and, apart from the lower temperature, where the amount of light is so much diminished.

Several theories have been brought forward to explain the cold of the Glacial Period, the generally received one being that of Mr. Croll, that it was brought about *indirectly* from an increase in the eccentricity of the earth's orbit, modified by the obliquity of the ecliptic. In the longer and colder winters more snow fell, which the summer could not melt away, so that the earth now covered gets little of the warmth of the sun. As this explanation has not always been thought quite satisfactory with regard to the greater warmth, the change of the position of the earth's axis has from time to time been suggested on various grounds.

It was suggested that there are three causes which might change the position of the axis, viz. distortion of the earth by continental and local upheaval altering the centre of gravity, and thus changing the position of the axis; the removal of water by elevation of land displacing the ocean; and the removal of matter in solution; and these two last, though not considered to be the most important in amount, were considered more in detail.

According to Mr. T. Mellard Reade,[1] about one ton of solid matter is removed in solution by the drainage of each square mile, so that about 5000 million tons are removed from the land surface each year; thus in ten years a weight equal to that of Vesuvius is removed from the land to the oceanic area by this means; and as there is more land in the northern hemisphere, this gives a gain for the southern hemisphere of 3230 million tons over the northern. If the earth is divided into a land and water hemisphere, with England as a centre, the gain of the weight of the water hemisphere is about 4300 million tons, or one Vesuvius in twelve years, the place of greatest gain being about 45° S. and the greatest loss 45° N. in antipodal positions.

A statement by Sir G. B. Airy in the *Athenæum*, 1860, was considered in order to see what effect special alteration would have. Removing a weight equal to that of Asia 1000 feet high from the centre of the land hemisphere, and adding a similar weight at the antipodes in a sinking Pacific Ocean, leaving the remaining portion in each hemisphere balanced by the natural configuration, would give an alteration of from 18–27 miles. This alone would require 13 million years at the present rate of denudation, but there are many causes, some of which were mentioned, which would very much reduce the time required for this amount of "soluble denudation," so that it might be reduced to one or two million years, and the vast thickness of calcareous rocks, which are only the record of others from which they were partly formed, shows how many times such areas must have been transported from land to sea.

The sinking of an area equal to the continent of Asia to the mean depth of the ocean would bring a weight of water sufficient, if the antipodes were a suboceanic rising area, to displace the position of the axis 40—60 miles by the same method of calculation. It is thus seen that these may be disturbing or starting forces, but do not give a large amount of change directly, and that the one to three degrees which Mr. George H. Darwin, M.A.,[1] allows is all that we should expect in recent geological times, unless there is some cumulative effect.

Mr. Waters maintained that if the change was caused by addition of weight, then the earth in re-adjustment would cause phenomena equivalent to an elevation in those semi-hemispheres from which the maximum bulge has been removed, displacing, if it should be an oceanic area, an amount of water to be placed in another region; the maximum effect of each degree of change is $\frac{1}{386}$ of the weight of the bulge, and the possibility of a redistribution of land and sea preventing a change in an opposite direction of the motion of the poles was pointed out.

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[1] In a paper on Geological Time, read as a presidential address to the Liverpool Geol. Soc. 1876-77.

[2] *Proc. Roy. Soc.*, No. 175, 1876.

The astronomical objections are that any such movement of the axis would be discoverable from the earth's and moon's motions, that is, by precession and nutation of the equinoxes, which are caused by the attraction of the sun and moon on the equatorial bulge. It is from no sufficient change in these motions that we have been told the figure of rotation has not altered in 3000 years (the limit of known observation), but this has been based upon a preternatural rigidity of the earth which is not now maintained by all physicists.[1]

It has been seen how the forces under consideration may have acted in opposite directions, and a consideration of recent geological phenomena shows that while large areas have been elevated it has not taken place steadily and uninterruptedly, but that there have been elevations and subsidences (or kindred phenomena) many times repeated, so that, if we turn to the north of Europe, to Belgium, or to Italy, we find, for a general elevation of a few hundred feet to have taken place since the middle of the Tertiaries, there have been subsidences and elevations of many thousand feet in each direction. Now, with the number of forces at work, and the irregular distribution of land and sea, it may be said that a reversal of conditions in one part could not take the axis back to exactly the same place; in other words, the axis might tack.

The great changes in the Tertiary period were briefly considered, showing how much change of level has taken place.

Mr. Waters said the points he wished to bring forward are, that a change of the position of the axis would elucidate many facts which have not yielded to any other explanation, and that a change of the position must take place, but that only a small amount could be directly proved; but if there is a cumulative effect, then it may be explained. The idea thrown out for examination by physicists was whether the frequent changes in direction which are caused by forces working in various parts of the world would not thus give a sufficient increase to the amount calculated.

Referring to recent papers bearing on this subject, the author adds:—

Since this paper was written, "Le Déplacement Polaire" of Dr. Jules Carret has come into my hands. This little work is written to demonstrate from various grounds that the position of the axis has changed, but without inquiring into the cause. The greater part of the book is devoted to proving that the present distribution of land and sea can only be accounted for by such a change, and this he thinks explains the polar land area and the antipodal position of nearly all the land to water areas. He shows that the effect of a change of position of the axis with the unequal diameters of the earth, which are unequally divided by the centre of gravity, will be to cause the land to be antipodal to the water, and the slight exceptions are near to the circumference, dividing the globe into land and water hemispheres, which is where the exceptions would be expected.

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[1] Sir William Thomson says in his Glasgow address: "A slow distortion of the earth as a *whole* would never produce any great angular separation between the instantaneous axis and axis of maximum moment of inertia for the time being."

By these exceptions he concludes that the poles have moved in a curved direction. If we divide the earth by a plane (grand circle polaire) perpendicular to the equator and to the direction in which the position of the poles have been changing, the points of intersection at the equator form two pivots for this motion, and here the effect of re-adjustment will be a minimum, while before and behind will be an area of elevation and submergence respectively. If the motion is curved, the plane (*g.c p.*) we have just supposed must cut the tangent of this curve at right angles. The changing position of this tangent changes the position of the plane, and the points of intersection are removed from the elevation to the submergence area on one side, and the opposite points from the submergence to the elevation area, so that land antipodal to land is the consequence.

REVIEWS.

I.—The Ancient Life-History of the Earth. A Comprehensive Outline of the Principles and Leading Facts of Palæontological Science. By H. Alleyne Nicholson, M.D., D.Sc., M.A., etc., Professor of Nat. Hist. in the University of St. Andrews. 8vo., pp. xvi. and 407, and 276 woodcuts. (Edinburgh and London, W. Blackwood and Son.)

IT affords us much pleasure to bring under the notice of our readers a recent publication, which, we trust, will be the means, at any rate to a great extent, of assisting the student of Palæontology in his battle with the many conflicting and unsolved problems of the science. In his "Palæontology" Professor Alleyne Nicholson treated the subject from a purely zoological point of view, as a branch of the comprehensive Science of Biology. In the present work, on the contrary, the same subject is discussed as a subdivision of Geology, from its historical aspect, with the introduction of purely structural details, only so far as may be necessary to a due understanding of the ancient forms of our globe. Such a work as the present is best appreciated by those who have gone beyond the mere threshold of palæontological science, and learnt how difficult it is in working up any given subject to obtain an epitome of the various views which have been passed upon it. The comparative absence of works such as Professor Nicholson's "Ancient Life-History" from our language is a fact we must all deplore, but one we hope ere long to see remedied to a great extent; and it is particularly on this account that the present work is the more welcome. True, we have Prof. Owen's "*Palæontology,*" a host in itself, the value of which was evinced by the fact that a second edition was called for before the book was a year old; but on the other hand, we have presented to us by our Continental brethren, as against this, such works as Pictet's *Traité de Paléontologie*, d'Orbigny's *Cours Elémentaire*, Vogt's *Lehrbuch der Geologie und Petrefactenkunde*, and, now publishing, Schimper and Zittel's *Handbuch der Palæontologie*.

Prof. Nicholson's "*Ancient Life-History*" is divided into two parts, "The Principles of Palæontology," and "Historical Palæontology." In the first the science is defined, the nature of fossils and process of fossilization described, the origin and mode of formation of sedimentary rocks discussed, and brief descriptions given of the chief kinds of the latter, illustrated by vignettes of microscopic sections of the rocks described. In the "Chronological Succession of the Fossiliferous Rocks" the student is taught the use of fossils, the assistance rendered by them in the sub-division and working out of the historical succession of the sedimentary formations, and due attention is paid that the student shall have a clear conception of the deductions to be drawn from an examination of any set of fossils, as to their age, origin, whether the deposit was accumulated under fluviatile, lacustrine, or marine conditions, and whether representing a littoral, deep-sea, or actual shore deposit. The evidence afforded by fossils as to climate is also dwelt on, but it is judiciously pointed out that all conclusions under this head, based as they are upon the present distribution of animal and vegetable life on the globe, must be accepted with caution, and may be, to a certain degree at least, vitiated or modified by certain well-established facts, such, for instance, as the occurrence of groups so unlike anything now existing that no theory as to the climate under which they existed can be drawn from them, neither is it certain that the habits and requirements of extinct animals were similar to their representatives of the present day. In the chapter devoted to "Breaks in the Geological and Palæontological Record," the contemporaneity of groups of strata is touched on, and it is pointed out by Prof. Nicholson that this may hold good for strata containing identical fossils within the limits of a single geographical region; but when the distance between the areas where the strata occur is greatly increased, the case is different, and is accounted for by a migration of the fauna, rather than that they were contemporaneous in the strictly literal sense of the term. The Geological and Palæontological records are considered to be sufficiently extensive to throw the balance of evidence in favour of the "continuity theory," as opposed to that of intermittent and occasional action in the production of life from the Laurentian upwards to the present day. The interruptions and breaks in the records are accounted for by the occurrence of an unconformability between any two sets of strata, supplemented by metamorphism, and supported by the absence of an appreciable number of animals, of which no trace is found in the fossil state. "Thus we arrive," says Prof. Nicholson, "at the conviction that *continuity* is the fundamental law of geology, as it is of the other sciences, and that the lines of demarcation between the great formations are but gaps in our own knowledge."

Under the "Biological Relations of Fossils" we are told that fossils "have relations of the most complicated and weighty character with the numerous problems connected with the study of living beings, or, in other words, with the Science of Biology." To such an extent is this the case that no adequate comprehension of Zoology and Botany, in their modern form, is so much as possible without some acquaintance with the types of animals and plants which have passed away."

Passing to the section of the work devoted to Historical Palæontology, there are a few points to which the attention of our readers is particularly directed. At the end of each chapter, representing a geological period, Prof. Nicholson has introduced a list of the more important and accessible works and memoirs bearing on the period, or its fossils, treated of, under the general heading "Literature." This feature has already been carried out by some German writers, notably by Carus and Gerstaecker in their "Handbuch der Zoologie," and its adoption by Prof. Nicholson will, we think, be of much assistance to the student, and add greatly to the value of the work. The stratigraphical sub-divisions of each period, irrespective of description, are well shown in the form of woodcuts representing vertical "generalized sections," demonstrating the order of succession of the various groups of strata, in one or other, and sometimes several of the countries in which the rocks comprising the period are best developed. Supplementary to these "generalized sections" are occasionally given "tabular views," in which are shown the equivalent sub-divisions of a formation in various countries, ranged in parallel columns. We can only notice with brevity a few of the more strictly important palæontological facts brought forward by the author. The reasons for supposing the existence of an abundance of life during the Laurentian period are clearly brought forward. Whilst speaking of Eozoon, the author considers "that the balance of evidence up to this moment inclines decisively to this view" (*i.e.* as to its organic nature). As a line of demarcation between the Cambrian and Silurian formations, Dr. Nicholson takes the Tremadoc slates, as proposed by Dr. Hicks. The structure of the Graptolites is entered into at some length, as might be expected from the author's well-known acquaintance with this family; he regards them as an ancient and peculiar group of Hydroida, and does not accept the Polyzoal affinities advocated by some writers. With regard to the advent of Vertebrates, we are reminded that the curious bodies from the Lower Silurian rocks of Russia, termed Conodonts by Pander, may yet prove to be the teeth of fishes, recent researches of Prof. Newberry having a tendency to establish Pander's original conclusion as correct. We regard Prof. Nicholson's remarks on the Devonian question with keen interest. With the view that the "Devonian formation has in nature no actual existence," advocated by some authorities, he does not concur, but considers that its flora and fauna, as a whole, are quite distinct both from the Silurian and Carboniferous. "This conclusion may be regarded as sufficiently proved even by the phenomena of the

British area; but it may be said to be rendered a certainty by the study of the Devonian deposits of the continent of Europe; or, still more, by the investigation of the vast, for the most part uninterrupted and continuous series of sediments which commenced to be laid down in North America at the beginning of the Upper Silurian, and did not cease till, at any rate, the close of the Carboniferous." This from one who has laboured so extensively as Prof. Nicholson has done, both as a geologist and palæontologist, amongst the rocks of that age in North America, is gratifying support to the Devonian advocates amongst ourselves.

Want of space quite prevents us following Prof. Nicholson step by step through his very interesting and instructive book, much as we are tempted to do so. We need only add that the same care and attention to detail is evinced in dealing with the Secondary and Tertiary formations as is shown in the earlier parts of the work. The concluding chapter is on "The Succession of Life upon the Globe," in which are summarized some of the principal results which may be deduced as to the succession of life upon the earth from the facts which have been passed in review in the preceding portion of the work.

Without coinciding with Prof. Alleyne Nicholson in all the views expressed in his latest work, yet we still feel ourselves authorized in considering the "Ancient Life-History of the Earth" as a desirable addition to every student's library, and as a work which will probably have a tendency to increase the study of Palæontology amongst us in no small degree. In the event of the book reaching a second edition, which we have no doubt it will, we would strongly advocate the insertion of a "generalized section" of the Scottish Carboniferous rocks for comparison with those of England, the very marked differences of deposition evinced by the Carboniferous series in North and South Britain being a point of considerable interest. Another point, and we have done. How much would the value of a work like the present be increased by the introduction of a few generic descriptions—descriptions of genera typical of each period into which the book is divided—terse, but to the point? We feel sure that an enlargement to this extent would repay the author for his trouble as much as it would afford instruction and pleasure to the reader. The book is printed in an exceedingly clear type, the illustrations are good, very numerous, and, so far as we are able to judge, accurate, and the whole work does the publishers much credit.

II.—WORKS OF THE PALÆONTOGRAPHICAL SOCIETY.

1.—MONOGRAPHS OF BRITISH FOSSILS. Published by the Palæontographical Society. Vol. XXVII. (for 1873). 4to. (London, 1874.)

THE continued enthusiasm and industry of veteran palæontologists, who have done much for the elucidation of British fossils in the earlier volumes of these Monographs, again offer rich stores to both systematic and amateur naturalists.

1. Dr. Wright gives part 6th of vol. i. of the Cretaceous Echinoderms, especially of the genera *Cottaldia*, *Discoidea*, and *Echinoconus*. In treating of the "Echinoidea exocyclica," the author takes great care to define the seven groups in which Breynius, one of the first and best of early Echinodermatologists, arranged the Echinidæ, with the synonyms used by others; and he gives a translation of the rare "Schediasma de Echinis," etc., from Breynius's "Dissertatio physica," etc., 1732.

2. Mr. Davidson adds to his immense collection of Brachiopodal literature and iconography some valuable supplemental notes, descriptions, and figures of Tertiary and Cretaceous species, either new or not sufficiently well known.

This enthusiastic student of Brachiopodal life-forms, having himself drawn on stone for the Society upwards of 200 quarto plates, often crowded with good figures, has thus enabled the Society to expend considerable sums on the illustration of other subjects, which would else have waited, perhaps in vain, for costly figuring.

3. Mr. S. V. Wood, the veteran geologist of the Crag, contributes a Supplement to his monographic account of the Bivalves of the Crag (and this Supplement is a monograph of itself, with 5 plates), some concluding remarks on the distribution of the Crag fauna, and an admirable "Synoptical List of Marine Mollusca from the Upper Tertiaries of the East of England," with remarks and an analysis of the list. The stratal grouping adopted[1] is (downwards):

	Post-Glacial; Valley Gravel, and Upland and Lowland Brick-earths.		
Plateau Gravel.	Post-Glacial, and Glacial (?).		
	Upper Glacial; the great Chalky Boulder-clay.		Glacial Beds.
	Middle Glacial; Sand and Gravel.		
	Lower Glacial	The Contorted Drift. The Pebbly Sand and Pebble-beds.	
	Chillesford Beds; Clay and Sand.		Upper Crag.
	Fluvio-marine Beds.		
Red Crag.	Red Crag, excepting the Scrobicularia-beds above, and the Walton Crag below.		
	Older or Walton Red Crag.		
	Coralline Crag.		Lower or White Crag.

"The results of the Table indicate," writes the author, p. 220, "an almost identical per-centage of forms not known as living in the case of the older Red Crag and the Coralline, which is in conflict with the geological break, which I still believe to exist between the two formations. With the exception of the Middle Glacial column of it, however, the Table shows very forcibly the diminishing Mediterranean aspect of the fauna as we ascend in the geological scale. In the Coralline Crag there are fifty-two Mediterranean forms not living in the British seas, and only twenty of the converse character; and of these twenty, two, viz. *Odostomia Gulsonæ* and *Psammobia tellinella*, are Lusitanian. In the Walton Red Crag the respective numbers are fourteen and thirteen; but in the rest of the Red Crag the British species not living in the Mediterranean are in number more than double those of the converse character; while in the Fluvio-marine Crag these proportions are increased five-fold; and in the Chillesford beds nineteen-fold. In the Lower Glacial there occur thirteen, in the Upper Glacial twenty-one, and in the Post-Glacial nineteen British species unknown in the Mediterranean; but in none of these three deposits does there occur a single species of the converse character.

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[1] See also the Introduction to this Supplement, Part 1, 1872, by S. V. Wood, Jun., F.G.S., and F. W. Harmer, F.G.S.

"Simultaneously with these features, we find . . . . . a proportional increase of the Arctic species as we ascend through the Crag and Glacial series; and that even in the Post-Glacial deposits no less than four out of a total of forty-nine are Arctic shells of the preceding Glacial Period, which have since receded from the British coasts.

"The Middle Glacial fauna stands out in some discord with the above; since in it not only do several Mediterranean species unknown to British seas reappear, but the proportion which these bear to the number of British species not known in the Mediterranean is as eight to twenty-one,—a much larger proportion than exists in the Fluvio-marine Crag, and altogether beyond the proportions exhibited by the intervening formations. The explanation is probably to be found in the Molluscan remains of this deposit having travelled from some distance, as mentioned in the Introduction to this Supplement, p. xxiii. Altogether this Middle Glacial assemblage is a very interesting one, and the most important of any of the formations succeeding the Crag. Several of the species which occur in it seem to have disappeared from the British coast during the earlier part of the Red Crag; and while some of these are not known living, others are confined to the Mediterranean or other southern waters.

"I have only to add that I am equally convinced with the authors of the Introduction to this work, that the Molluscan remains of the Middle Glacial Sand (fragmentary and worn as they occur in it) are not derived from any older deposit, but are contemporaneous with the sand which contains them."

4. To osteologists, and those who study the fossil dragons of the Wealden and Purbeck formations, the continued labours of the indefatigable Professor Owen bring grand results in the descriptions and figures of remains of *Iguanodon Mantelli*, *I. Hoggii* (?), *I. Foxii*, *Hylæochampsa Vectiana*. In the same volume the author continues his researches on the Mesozoic *Pterosauria*, describing and illustrating many relics of Pterodactyles from the Gault, Hastings Beds, Kimmeridge Clay, Great Oolite, and the Lias.

2.—MONOGRAPHS OF BRITISH FOSSILS. Published by the Palæontographical Society. Vol. XXVIII. (for 1874). 4to. (London, 1874.)

I. This volume has fewer Monographs, or parts, than usual; but one, and that fortunately a *complete* work, is bulky in text and enriched with sixteen plates, which have an average of upwards of 30 figures in each! These (all drawn by G. S. Brady, and lithographed by T. West and G. West) illustrate the minute Bivalved Entomostraca which occur plentifully in many clays and loams of Post-Tertiary date, and have their analogues, and often their exact representatives, in the existing seas, lakes, and rivers. The Palæontographical Society has already published Monographs by Rupert Jones on the Cretaceous and Tertiary species; and the present Monograph, by Dr. G. S. Brady, a first-rate carcinologist, with whom the Entomostraca are favoured pets, aided by two careful naturalists and geologists, Messrs. H. W. Crosskey, F.G.S., and D. Robertson, F.G.S., advances our knowledge of these small, but true and useful witnesses of past conditions, bringing them *en rapport* both with those that are found fossil in older deposits and those now living. The classification of the *Ostracoda* (the special group of Bivalved Entomostraca treated of in this Monograph), according to the shape, texture, markings, and hingement of the valves, at pages 109–114, and the synopsis of their genera, based upon the anatomical characters of the animal, at pp. 115 and 116, will be highly acceptable to the students both of recent and of fossil specimens; and indeed these admirable synopses are full of the latest information, derived from the researches chiefly of Dr. G. O. Sars, of Norway, and Dr. Brady himself.

"Of the 132 species of Ostracoda described in this Monograph, 24 may be considered to have been inhabitants of fresh or slightly brackish water, the remaining 108 being strictly marine species." The freshwater species are as follows:—

Cypris cinerea, Brady.
——— *compressa*, Baird.
——— *gibba*, Ramdohr.
——— *ovum*, Jurine.
——— *reptans*, Baird.
——— *salina*, Brady.
——— *virens*, Jurine.
——— *lævis*, Müller.
Cypridopsis Newtoni, B. & R.
——— *obesa*, B. & R.
Candona albicans, Brady.
——— *candida*, Müller.
Candona compressa, Koch.
——— *detecta*, Müller.
——— *lactea*, Baird.
Potamocypris fulva, Brady.
Darwinella Stevensoni, B. & R.
Limnicythere antiqua, n. sp.
——— *inopinata*, Baird.
——— *monstrifica*, Norman.
——— *Sancti-Patricii*, B. & R.
Cytheridea lacustris, Sars.
——— *torosa*, Jones.
Loxoconcha elliptica, Brady.

All except *Limnicythere antiqua* are known in the living state. Of the marine forms found in the Post-Tertiary beds there are lists given,—1. Of those now known as characterizing the Arctic seas and the northern coasts of Norway, Scotland, and America. 2. Those now extinct, or unknown in the living state. 3. Those found in the Glacial and Post-Glacial deposits of Norway. 4. Those found in the Glacial (and Post-Glacial ?) deposits of Canada.

The Introduction of this Monograph (pp. 1—108) is essentially geological, being descriptive of the numerous Post-tertiary clays and sands associated with the beds which have yielded the Ostracods under notice. In fact this portion of the work is a Monograph on the Post-tertiary beds of Scotland and the north of England, with notices of others beyond those limits. After a definition of terms, our authors proceed to describe: 1. The local varieties of Boulder-clay, both with and without fossils (pp. 3—10); 2. The varieties of fossiliferous deposits, not being Boulder-clays and not Post-Glacial (pp. 11—25); these may be (*a.*) "immediately beneath the Boulder-clay, and either Preglacial, Interglacial, or Glacial, without having any Boulder-clay for their base;" (*b.*) "between masses of Boulder-clay;" (*c.*) "clays, sands, and gravels characterized by a fauna more or less intensely Arctic;" (*d.*) "clays and sands, characterized by an Arctic fauna, either immediately overlying Unfossiliferous Boulder-clay, or separated from it by a thin seam of 'Laminated Clay.'" 3. The Ostracodiferous beds (pp. 25—92): A. "characterized by an Arctic fauna;" B. "the characteristics of the Arctic-shell beds."—not necessarily belonging to *one* age, and fluctuations of climate may have taken place; the difference of these Arctic beds summarized; C. "series of beds of later date, and not in any way Arctic, indicating the steps through which the present physical geography of Scotland

as been reached since the retreat of the ice;" (*a.*) "deposits
ossibly belonging to a period of warmer-climate conditions than
ow exist;" (*b.*) "series of Post-glacial deposits belonging to the
ost recent period of the depression of the land,"—such as Raised
eaches and Estuarine Muds. 4. "General sequence of the Post-
ertiary beds of Scotland,—Preglacial, Early Glacial, Middle Glacial,
inal Glacial, Early Post-glacial, Middle Post-glacial, and Final
ost-glacial; the termination of the Period being marked by the
ost recent elevation of the land" (pp. 93—96). 5. "Relationships
etween the Glacial fauna of Scotland, the Recent British fauna, and
he Glacial fauna of Norway and Canada, established by Ostracoda
s well as by Mollusca" (pp. 96—99). 6. English, Irish, and
Velsh Post-tertiary deposits examined for Entomostraca (pp. 100—
08).

When we consider that fifty principal localities of the Post-tertiary
stracoda are here systematically treated of, we can form some
otion, not only of the mass of geological information brought
ogether in this Monograph, but of the importance of these minute
ossil Entomostraca among the "Medals of Creation." An elaborate
able of the Distribution of the Fossil Ostracoda over the Post-
ertiary Localities, a copious Table of Contents, and a good Index
f generic and specific names, greatly add to the value of this
onograph.

The "Journal of Bores at Garvel Park," given at p. 44, etc., we
ay mention, is not a private diary of self-complacent noodles,
edants, and witlings at a dull country-house; but a strictly *pro-*
essional illustration of the good old mole-like geologist's motto—
'I bore."

II. The next constituent of the 1874 Volume is Part I. of a
onograph of the British Fossil Bivalved Entomostraca from the
arboniferous Formations, by T. Rupert Jones, J. W. Kirkby, and
. S. Brady; and this first portion is devoted to "the Cypridinadæ
nd their Allies." Some parts of the Mountain Limestones of various
ountries seem to abound in subglobular bivalve carapaces, and their
oose valves, which approximate in character to various members of
he Cypridinad group; some are also found in the Coal-measures;
nd others in the older Devonian, and even in the Silurian rocks.
hey are associated frequently with other Ostracodous valves, such
s *Beyrichia, Leperditia, Cytheridæ,* and *Cypridæ* of various alliances.
n this part of the Monograph we find 13 *Cypridinæ* (directly related
o the existing *Cypridina*); 7 *Cypridinellæ,* 9 *Cypridellinæ,* 6 *Cypri-*
ellæ, and 2 *Sulcunæ,* which are genera arranged artificially to
eceive several forms of carapace varying by gradational differences
rom the valves of the known *Cypridina;* 2 *Cyprellæ;* 1 *Brady-*
inetus; 1 *Philomedes;* and 2 *Rhombinæ,* of which much the same
ay be said as of the foregoing; also 4 *Entomoconchi,* 1 *Offa,* and
Polycopes. The definition of the true *Cypridinæ,*—the true alloca-
ion of the several species placed by De Koninck under *Cyprella,*
ypridella, and *Cypridina,*—and a more exact interpretation of
'Coy's *Entomoconchus,* are (besides many new species) the chief

novelties of this memoir, which is illustrated by five plates (by George West) very full of excellent figures of these small fossils.

III. Another instalment (No. 2) of Dr. Lycett's "Monograph of the British Fossil Trigoniæ" concludes this Fasciculus, with his careful and valuable account of these interesting fossils, chiefly "Undulatæ," with some "Clavellatæ" and some "Glabræ," and with ten exquisite plates of Jurassic Trigoniæ, drawn by P. Leckerbauer, in Paris.

3.—MONOGRAPHS OF THE PALÆONTOGRAPHICAL SOCIETY FOR 1875. Vol. XXIX.

THE study of fossilized organic remains has an ever-increasing interest,—to the geologist, because thereby he gets the means of distinguishing one set of strata from another, more and more definitely according to the exactness by which the remains of successive creatures are discriminated,—to the biologist, because more and more of the missing links of the organic world in all its stages are brought to light,—and to the general observer, because he wishes to know, for knowledge sake, what manner of creatures were the animals or plants whose only relics are obscurely enwrapped in the fossiliferous clay or stone which comes under his notice.

The volume of Monographs (vol. xxix.) issued by the Palæontographical Society for 1875 comprises 1st, a communication (Part iv.) of Mr. Binney's well-illustrated monographic study of the Plants found in the Coal-measures of Great Britain. *Sigillaria* and *Stigmaria* are the special objects in hand, and are elucidated by numerous microscopic observations on slices of well-preserved specimens from the author's rich collection, and beautifully drawn by Fitch. He here gives a bibliographic summary of the present state of our knowledge on the structure of *Sigillaria* and allied plants (*Anabathra, Diploxylon*, etc.); together with further information on *Sigillaria vascularis*, Binney, a description of a *Stigmaria* agreeing with that plant in structure, and special notes on the base of *Sigillaria* and the rootlets of *Stigmaria.*

2nd.—Dr. Wright's continuation of his Cretaceous *Echinodermata*, such as the *Echinoconidæ, Echinonidæ, Echinobrissidæ, Echinolampidæ*, and *Spatangidæ;* these are illustrated by many excellent figures by the late C. Bone.

3rd.—Part 3 of Dr. Lycett's Monograph on the British fossil *Trigoniæ* (beautifully drawn by Leckerbauer). Like the foregoing, this is very welcome to British palæontologists, whether they wish to have the natural history and synonymy of these important groups soundly settled, or to be able to arrange their specimens systematically in their cabinets.

4th.—The remains of *Bothriospondylus* from the Forest-marble and the Kimmeridge Clay enable Prof. Owen to demonstrate the presence of true *Saurian*, and absence of *Ornithic* characters in this great Reptile. The short Monograph on the genus *Cetiosaurus*, pp. 27—43, concentrates and criticizes what has been hitherto published on *this great* aquatic Dinosaur, as exemplified by the magnificent specimens of *C. longus*, Owen, in the Oxford Museum. The fine series of remains of a gigantic Cetiosauroid Dinosaur (*Omosaurus armatus*, Owen), from the Kimmeridge Clay at Swindon, furnishes material for a Monograph, with twelve large plates beautifully drawn by C. L. Griesbach; and enables Prof. Owen to enlarge upon the "life and affinities of *Dinosauria*, as elucidated by the known character of *Omosaurus*." The classification of fossil Saurians by H. von Meyer, and the opinions of Prof. Huxley as to the ornithic affinities of the Dinosaurs, are criticized in detail; and the relative smallness of the fore-legs of these great Reptiles is regarded as analogous to that in swimming Crocodiles, and not as having reference to an upright position on their hind-legs in moving on the land.

4.—MONOGRAPHS OF THE PALÆONTOGRAPHICAL SOCIETY FOR 1876.

THE volume for 1876 (vol. xxx.) has (1st) a short Supplement to Prof. Owen's Fossil Reptilia of the Wealden Formation, in which he describes and illustrates a new species of *Poikilopleuron* (*P. pusillus*, Owen), with its cavernous vertebræ, in which ossification had been arrested; also a new genus of gigantic and probably Dinosaurian Reptiles, in which such chondrosal cavities, due to the partial retainment of the primitive chondrine, are very characteristic. Two species of this great *Chondrosteosaurus* are known from the Wealden (one of them had been previously referred to *Bothriospondylus*).

2nd.—The British Fossil Brachiopoda are further elucidated and systematized by Mr. Davidson, who has enthusiastically devoted so much time and labour to mastering and explaining the characters and relationships of this most interesting group of shells. Those of the Triassic and Jurassic species which had previously escaped notice are now described, and additional notes on those already known enhance the value of this magnificent Monograph. Plates IX. to XVI. are given with this portion, and illustrate the Jurassic *Tretenterata* and *Clistenterata*.

3rd.—H. B. Brady's Monograph of Carboniferous and Permian Foraminifera (the genus *Fusulina* excepted), 166 pages, with 12 plates, is one of the most exhaustive and perfect Monographs yet supplied by the Palæontographical Society. The Introduction tells of the history of the undertaking, and enumerates the author's fellow-workers and helpers. Under "General Considerations" he tells us of the relationship of limestones and *Foraminifera;* pointing out that only some limited portions of the Mountain-limestone appear to be formed of *Foraminifera* in the British and West-European area, though *Fusulina* constitutes enormous masses of that limestone in Russia and North America. Indeed, he considers that there are large areas of this limestone where the sea appears to have deposited its excess of mineral constituents by chemical precipitation, resulting in concretional, spheroidal, or oolitic structures; organic remains, if not absent, having been either dissolved or masked. The *rationale* of the necessary physical conditions and changes is briefly explained. The occasional presence of *Foraminifera* in prepared slices of the British Carboniferous and Permian limestones (for these formations are treated of together), and the more frequent opportunities of finding them afforded by the disintegrated shaly wayboards, or partings, of the limestone, are also noticed.

The "Zoological Considerations," of especial interest to the Rhizopodist, comprise a critical review of von Reuss' and Carpenter's classifications of *Foraminifera*, and a general comparison of the generic forms known in the Carboniferous strata with those now living. The conclusions arrived at are—1st. The prevalent forms (except *Fusulina*) in the Carboniferous and Permian limestones do not belong strictly to either of the two sub-orders (*Imperforata* and *Perforata*) into which *Foraminifera* have been divided, but to intermediate types (especially *Trochammina*, *Valvulina*, *Endothyra*, *Nodosinella*, and *Stacheia*), neither invariably arenaceous nor uniformly perforate in their shell-texture. 2nd. In the modifications of these primitive intermediate types there are some varieties conspicuously sandy and imperforate, others essentially hyaline and porous; and these varietal peculiarities seem to have been transmitted as permanent characters, thereby originating the two parallel isomorphic series. 3rd. The porcellanous imperforate group (*Miliolida*) is of later creation, judging from negative evidence. 4th. The Permian Rhizopod-fauna is much more limited than the Carboniferous, being confined to five generic types (*Trochammina*, *Nodosinella*, *Nodosaria*, *Textularia*, and *Fusulina*), representing, however, at least four distinct families of *Foraminifera*, which in the Carboniferous rocks are represented by fifteen genera.

In the "Geological and Geographical" section, Mr. Brady gives a catalogue of the localities from which, with the aid of many friends, he obtained the *Foraminifera* described and figured in this Monograph. The exact geological horizon is duly indicated, whenever ascertained. The North of England, Midland Counties and Wales, Bristol District, Scotland, Ireland, Belgium, Russia, and North America are the regions, subdivided into many districts, whence have come the 142 specimens of Carboniferous rocks, which yielded *Foraminifera* to Mr. H. B. Brady's careful, and indeed laborious, examination. Very many specimens of the Magnesian Limestone of England and Ireland, and the Zechstein and Kupferschiefer of Germany have been thoroughly searched by our indefatigable author for the Permian Foraminifers.

The "Bibliography," pp. 51–55, comprises the titles and dates of the books and memoirs referred to in the Monograph; they reach from 1826 to 1876.

The following genera and species are described and figured. The plates have been exquisitely lithographed by A. T. Hollick after Mr. Brady's drawings:—

SACCAMMINA, Sars.
    Carteri, Brady.
LITUOLA, Lamarck.
    nautiloidea, Lamarck.
    Bennieana, nov.
HAPLOPHRAGMIUM, Reuss.
    rectum (Brady).
CLIMACAMMINA, Brady.
    antiqua, Brady.
TROCHAMMINA, Parker & Jones.
    incerta (d'Orbigny).
    centrifuga, Brady.
    anceps, nov.
    annularis, nov.

Trochammina, Parker & Jones.
gordialis, Parker & Jones.
pusilla (Geinitz).
milioloides, P., J., & K.
Robertsoni, nov.
filum (Schmid).
Valvulina, d'Orbigny.
palæotrochus (Ehrenb.).
—— var. *compressa*, Brady.
Youngi, Brady.
—— var. *contraria*, Brady.
decurrens, Brady.
plicata, Brady.
bulloides, nov.
rudis, nov.
Endothyra, Phillips.
Bowmani, Phillips.
ammonoides, Brady.
globulus (d'Eichwald).
crassa (Brady).
radiata (Brady).
macella (Brady).
ornata (Brady).
—— var. *tenuis*, nov.
obliqua (Brady).
subtilissima, nov.
Nodosinella, gen. nov.
digitata, nov.
Nodosinella, *cylindrica*, nov.
priscilla (Dawson).
concinna, nov.
lingulinoides, nov.
Stacheia, gen. nov.
marginulinoides, nov.
fusiformis, nov.
Stacheia, gen. nov.
pupoides, nov.
acervalis (Brady).
congesta, nov.
polytrematoides, nov.
Lagena, Walker & Jacob.
Parkeriana, nov.
Howchiniana, nov.
Lebouriana, nov.
Nodosaria, Lamarck.
radicula (Linné).
Dentalina, D'Orbigny.
communis, d'Orbigny.
multicostata, d'Orbigny.
Textularia, Defrance.
gibbosa, d'Orbigny.
eximia, d'Eichwald.
Jonesi, nov.
triticum, Jones.
multilocularis, Reuss.
Bigenerina, d'Orbigny.
patula, nov.
Truncatulina, d'Orbigny.
carbonifera, nov.
Boueana, d'Orbigny.
Pulvinulina, Parker & Jones.
Broeckiana, nov.
Calcarina, d'Orbigny.
ambigua, nov.
Archædiscus, Brady.
Karreri, Brady.
Amphistegina, d'Orbigny.
minuta, nov.
Nummulina, d'Orbigny.
pristina, Brady.

The exposition of the structure of *Valvulina* and *Endothyra* and their interesting subarenaceous allies, already noticed,—and the discovery of the *Rotalinæ* (*Truncatulina*, *Pulvinulina*, *Calcarina*), and of the *Nummulinidæ*, (*Archædiscus*, *Amphistegina*, and *Nummulina*) in the Carboniferous Limestones, are some of the most important points in this excellent Monograph; and its value is greatly enhanced by eight elaborate Tables, special and general, showing in great detail the geological and geographical distribution of the 58 species, according to their localities and stratal horizons in the many districts whence they were obtained. A perfect Index for genera and species and their synonyms completes the volume. T. R. J.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—March 21st, 1877.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.

The following communications were read:—

1. "On the Strata and their Fossil Contents between the Borrowdale Series of the North of England and the Coniston Flags." By Prof. Robert Harkness, F.R.S., F.G.S., Professor of Geology in Queen's College, Cork, and H. Alleyne Nicholson, M.D., D.Sc.,

F.R.S.E., F.G.S., Professor of Natural History in the University of **St. Andrews.**

The object of this paper was the investigation of the strata between the great volcanic series of the Lake-district, the Borrowdale rocks, and the sedimentary rocks called Coniston Flags by **Prof. Sedgwick. The Borrowdale series, the Green Slates** and **Porphyries of Sedgwick, are underlain by the Skiddaw Slates, forming the base of the Silurian series, and equivalent in age to the Arenig rocks of Wales, according to their fossil contents. The Borrowdale rocks consist of ashes and breccias, alternating with ancient lavas, and are partly subaerial, partly submarine. They contain no fossils except in a band of calcareous ashes near the summit of the group, which is followed by the Conistone Limestone, with or without the intervention of a bed of trap. The fossils are of Bala types. Sometimes this band is recognizable, with no traces of fossils except cavities filled with peroxide of iron. The authors regard this as proving the prevalence of volcanic activity in the Lake District up to the later portion of the Bala period.**

The deposits specially discussed in the paper sent, lie, apparently quite conformably, upon the Borrowdale rocks, and are grouped by the authors as follows, in ascending order:—

1. **Dufton Shales.**
2. **Coniston Limestones and Shales.**
3. **Graptolitic Mudstones or Skelgill Beds.**
4. **Knock Beds.**

The "Dufton Shales" are a well-marked, but locally distributed group of muddy deposits, especially well developed in the Silurian area underlying the Cross Fell range, where they are seen in four principal exposures, and their thickness probably exceeds 300 feet. They are richly fossiliferous, the fossils being generally of Bala types; and they may be regarded as forming, palæontologically, the base of the Coniston Limestone. The fossils sometimes occur in ash-beds; and the continuance of these conditions leads the authors to believe that there was no break between these shales and the underlying Borrowdale rocks.

The "Coniston Limestone" has long been recognized as the best-defined division of the Lower Silurian rocks of the north of England. Its range and characters, and those of the associated shales in different localities, are indicated by the authors; and from the contained fossils, they refer it, at least approximately, to the horizon of the Welsh Bala Limestone, whilst they regard it as the precise equivalent of the Lower Silurian of Portraine (co. Dublin), and of that of the Chair of Kildare, both of which are of Bala age.

The "Graptolitic Mudstones" overlie the Coniston Limestone, wherever the summit of the latter is to be seen. Besides Graptolites, they contain many other fossils, including Corals, Brachiopods, Cephalopods, and Crustaceans; and from the consideration of the whole fauna, the authors are led to believe that the position of these deposits must correspond either with the highest beds of the Bala series, or with the lower portion of the Llandovery group. In their opinion, there is perfect conformity between the Mudstones and the underlying Coniston Limestone. They regard the Graptolitic Mudstones as constituting a definite geological horizon of more than local importance, as they have been recognized in Ireland, Sweden, Carinthia, and Bohemia.

The Graptolitic Mudstones are succeeded by the "Knock beds," so called from their great development in Swindale Beck, near Knock. Wherever they occur, they consist chiefly of pale-green, fine-grained slates, very ashy in appearance, and presenting many dendrites, and frequently crystals of cubic pyrites. There is no evidence of unconformity between them and the underlying Mudstones. The former contain scarcely any fossils. They are directly surmounted by the "Coniston Flags," representing the Denbighshire Flags of North Wales, which have been shown to be of Upper Silurian age. Hence the authors conclude that the Knock beds must be either the basement series of the Upper, or the summit series of the Lower Silurian, or else a group of passage-beds between the two. The palæontological evidence is insufficient to settle the point, but it tends to show that the Knock beds are at the base of the Upper Silurian, an opinion which is corroborated by their lithological resemblance to the Tarannon slates of Wales.

The paper concluded with an appendix on the Irish rocks referred to above.

2. "On a new Area of Upper Cambrian Rocks in South Shropshire, with the Description of a new Fauna." By C. Callaway, Esq., M.A., F.G.S.

The purpose of the author was to prove that certain olive, micaceous, thin-bedded shales exposed at Shineton, near Cressage, and covering an area of eight miles in length by two in the greatest breadth, which had been mapped as Caradoc in the survey, were of Tremadoc age. They were seen clearly to underlie the Hoar Edge Grit, the lowest beds in the district, with Caradoc fossils; and no rock distinctly underlying the shales could be detected. The evidence for their age was chiefly palæontological. With the exception of *Asaphus Homfrayi*, a Tremadoc form. the species are new. Genera such as *Olenus*, *Conocoryphe*, *Obolella*, and *Lingulella*, suggested a very low horizon, but two Asaphoid forms (though not typical *Asaphi*) pointed in an opposite direction. Corroborative evidence was found in a correlation of the shales at Shineton with the *Dictyonema*-shales at Pedwardine and Malvern. It was shown from lithological characters and from fossils that the shales at the three localities were of the same age; and as the beds at Pedwardine and Malvern were, on their own testimony, admitted to be of *Lingula*-flag or Tremadoc age, the Shineton shales were inferred to be on the same horizon, the Asaphids leading the author to adopt the younger of the two formations. He was of opinion that the Black Shales of Malvern (Dolgelly beds) were not represented in the Shineton area. He announced the discovery of the Hollybush Sandstone, forming a continuous band between the Shineton Shales and the Wrekin axis, recognized by the occurrence of *Kutorgina* *cingulata*, and probably separated from the shales by a fault. This also afforded corroborative evidence of the identity of the *Dictyonema*-shales with the shales at Shineton.

II.—April 11th, 1877.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.

Shells from raised beaches, Blackcliff Bay and Port Foulke, lat. 82° 35′ N., were presented to the Museum by Lieut. George le Clerc Egerton, R.N.

The following communications were read:—

1. "On Sandworn Stones from New Zealand." By John D. Enys, Esq., F.G.S.

The author exhibited specimens of sandworn pebbles from near Wellington in New Zealand, and described their mode of occurrence. They are found on an isthmus rising but little above the sea, and about a mile wide, and having on each side a line of low sand-hills, separated by a flat space of clayey sand, on which the stones rest. The isthmus separates two bays, on each side of which the ground is high, and hence the prevailing winds (which are north-west and south-east) blow across the isthmus with considerable force, and carry with them a cloud of sand, which, on a windy day. forms a dense mass, reaching about to the knees of a person walking over the ground. The passage of this moving sand over the stones or pebbles lying on the surface wears them away so as to give them sloping sides, and even to bring them to an angle or ridge running along the upper surface, the direction of the longer axis of the stone with respect to the prevailing wind governing the particular form assumed by the worn stone. Where veins of harder material occur in the stones, these are left projecting from the surface, and are sometimes even undercut.

2. "The Bone-caves of Creswell Crags."—Third Paper. By the Rev. J. Magens Mello, M.A., F.G.S.

In this paper the author gave an account of the continued exploration of these caves, and of the completion of the examination of the Robin Hood Cave, noticed in his previous communications. Five deposits could be distinguished in the Robin Hood Cave, namely, when all present:—

1. Stalagmite, 2 ft.
2. Breccia, with bones and flint implements, 1 ft. 6 in.
3. Cave-earth, with bones and implements, 1 ft. 9 in.
4. Mottled bed, with bones and implements, 2 ft.
5. Red sand, with bones and quartzite implements, 3 ft.

Variations both in thickness and in character occur in different parts of the cave. The surface-soil yielded traces of Romano-British occupation, such as enamelled bronze fibulæ, fragments of pottery, &c. The most important discoveries were made in the cave-earth, and chief among these was a fragment of bone, having on it a well-executed outline of the head and neck of a horse, the first recorded discovery of any such work of art in this country. The cave-earth also yielded a canine of *Machairodus latidens*, hitherto obtained in

England only in Kent's Hole. Numerous remains of the Pleistocene mammalia already recorded were found, together with a great number of implements of quartzite and flints, and two of clay ironstone. The quartzite implements were most abundant in the lowest bed.

In the other cave examined, the Church Hole, which consists principally of a long fissure in the south side of the crags opposite Robin Hood's Cave, the succession of beds was nearly the same as in the latter. In the surface-soil near its mouth a fine bronze brooch was found. Some of the implements met with in the cave-earth were of great interest, and several of them were of bone. Bones of Rhinoceros were found in great abundance; and those of the Mammoth, Horse, etc., were also plentiful.

As the result of the exploration of these caverns, the author said it is evident that during the Pleistocene period Derbyshire and the adjoining counties were inhabited by a very numerous and diversified fauna, the vast forests and pastures which extended far to the east and south offering a congenial home to the Mammoth, the Woolly Rhinoceros, the Hippopotamus, the Irish Elk, the Reindeer, the Bison, and the Horse, whilst among them the Hyæna, the Glutton, the Bear, the Lion, the Wolf, the Fox, and the great sabre-toothed *Machairodus*, roamed in search of prey; and that with these and other animals man lived and waged a more or less precarious struggle, amidst the vicissitudes of a varying climate, sheltering himself in the numerous caves of the district, which were already the haunts of the hyæna and its companions.

3. "On the Mammal-fauna of the Caves of Creswell Crags." By Prof. W. Boyd Dawkins, M.A., F.R.S., F.G.S.

In this paper the author gave an account of the remains found in the caves explored by the Rev. J. M. Mello. He stated that the recent explorations had proved that the Robin Hood Cave was inhabited by Hyænas, not only during the deposition of the cave-earth and breccia, but also during that of the red-sand clay underlying it, which had also furnished traces of the existence of man. An immense number of specimens were collected in this cavern, including bones of the following animals:—*Machairodus latidens*, Cave-Lion, Wild Cat, Leopard, Spotted Hyæna°, Fox°, Wolf, Bear, Reindeer°, Irish Elk°, Bison°, Horse°, Woolly Rhinoceros°, Mammoth°, and Hare°; those marked with ° occurring in the red sand and clay as well as in the cave-earth, although much more sparingly. The traces of man consisted of more than 1000 implements; and, as before, those made of quartzite were generally found in the lower strata. The most important indication of human handiwork was the outline of the head and fore-quarters of a horse, engraved upon the fragment of the rib of some animal. Among the animal-remains the most interesting discovery was that of a canine of *Machairodus latidens;* it consisted of the sabre-shaped crown only, which appeared to have been purposely broken away from the root.

The superficial layer of earth in the cave contained remains belonging to the historic and prehistoric ages, including a Romano-British enamelled bronze brooch, of the same pattern as one found in the Victoria Cave; fragments of pottery, human bones and teeth, and bones of both wild and domestic animals.

The distribution of the remains found in the Church Hole Cave agreed generally with that above described; traces of human occupation and remains of the Hyæna occurred both in the cave-earth and in the red sand and clay. The bones found indicated the following animals:—Lion, Polecat, Hyæna, Fox, Wolf, Bear, Reindeer, Irish Elk, Bison, Horse, Woolly Rhinoceros, Mammoth, and Hare—all common to both the cave-deposits, except the Lion, which was found only in the cave-earth, and the Polecat, of which a single jaw occurred in the red sand. The latter contained a larger proportion of the remains than in the Robin Hood Cave, but, as in the latter, the quartzite implements were more abundant in the lower strata of the deposits. Among the articles of human workmanship was a perfect and well-shaped bone needle. The superficial soil of the Church Hole Cave also contained articles of the historic and prehistoric age, including a bronze fibula, fragments of pottery (one mediæval), and bones of man and animals. From the presence of these objects in the surface-soil the author inferred that the caves of Creswell Crags, like those of Yorkshire and elsewhere, were used as places of refuge by the Brit-welsh during the conquest of the country by the English.

After noticing the conditions of the fossil bones found in the caves, the author proceeded to remark upon the general results of the explorations with regard to their Pleistocene fauna, and concluded that there is no evidence from these or other caves in this country to prove that their faunas are either pre- or interglacial, and that we have no proof of the existence of pre- or interglacial man in Britain.

CORRESPONDENCE.

THE MAGNESIAN LIMESTONE AND NEW RED SANDSTONE IN THE NEIGHBOURHOOD OF NOTTINGHAM.

Sir,—Assuming that I am one of the "local geologists" referred to by Mr. Aveline in his notice on the above subject, published in the April Number of the Geological Magazine, I must, speaking for myself alone, take exception (1) to his definition of my position, and (2) to the necessity for the inference that he draws from facts in themselves not open to question. In a paper on the Permians of this district, Q. J. G. S. Nov. 1876, I briefly referred to a series of sandstones, marls, and breccia, that I had long since noticed in the neighbourhood of Nottingham to intervene between the typical Lower Bunter (f^1) and the Middle Permian marls (e^3). On account of their combining the textural characters of both these sub-formations, it became extremely difficult to relegate them to one or the other; and some geologists were inclined to class them as passage-beds. In the above paper and accompanying section it was my intention to refer to, but not to sanction this idea, as an impartial critic will, I think, readily perceive. To speak candidly, these beds require further study before their precise relationship can be satisfactorily determined.

While by no means prepared to affirm that "a perfect conformity exists between the Magnesian Limestone and the New Red (meaning Bunter) Sandstone in the N.E. of England," I differ widely from Mr. Aveline, in his view that there is proof of a great break between these formations. In support of this position, he cites the successive overlaps of the Upper Permian Marls and Limestone, Middle Marls and Lower Limestone, by the Bunter Sandstone, going south, from the district north of Worksop, to the latitude of Nottingham.

But has it ever occurred to him that all these cases may be of the nature of conformable overlaps? My own experience of the Marl Slate, Lower Magnesian Limestone, and Middle Marls of this district, founded on accumulated data, not attainable in Mr. Aveline's time, convinces me that there is a general tendency in these subformations to attenuate *inter se*, as also to become coarser in texture, when followed from the north or north-east towards the south or south-west. To cite one or two instances of this. The attenuating Lower Magnesian Limestone, which, for the last few miles of its southern extension, has become in great part a flaggy, sandy, and even conglomeratic rock, dies out as a coarse brecciated littoral deposit. The Middle Marls[1] have just previously faded away. Simultaneously, the Marl Slate series has diminished from 60 or 70 feet of shales (mostly), to 20 feet of sandstones (mostly), and from that to *nil*, when the basal Permian, a coarse brecciated rock, comes directly beneath the last degraded relic of the Magnesian Limestone.[2] These facts in my opinion point to the existence of an inter-Permian marginal barrier immediately to the south, and somewhat more remotely to the west, and to successive synchronous increments of subsidence in the opposite directions.

I do not believe that any of the above rock series ever stretched appreciably further south than they do now. Extending this reasoning to the Upper Magnesian Limestone and uppermost Permian Marls (as to which my data is admittedly more limited), I would suggest that they never extended appreciably further south than they respectively do now, and that their southerly disappearance is due to analogous causes. Successive increments of subsidence in a north-easterly direction will account for these phenomena. Inter-Bunter-Permian denudations will not. Small local irregularities undoubtedly exist between the Lower Bunter and (the marginal) portions of certain of the Permian sub-divisions owing to the minor oscillations, resulting in partial failures of deposition and paltry denudations, to which all shallow-water deposits of limited thickness are liable. These were, however, probably mostly inter- rather than post-Permian. Such, for instance, are the cases mentioned in the Survey Memoirs, near Mansfield and Tadcaster, where Middle Permian Marls rest on an eroded surface of the Lower Magnesian Limestone, which at the former place is full of false bedding, and at both exhibits signs of having been sufficiently close to the surface to have locally curtailed or even entirely excluded the deposition of the Middle Marls. I would insist on the importance of discriminating between what is the result of contemporaneous influences (great and small), and what of subsequent causes, in limiting the extension of the Permian formations. If we consent to exclude all evidence that is not provably post-Permian, I think we have yet to learn the grounds for considering that there was in the above district any "considerable break" between the Permian and the Bunter.

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[1] The persistent outcrop of this thin and denudable series between the Magnesian Limestone and Lower Bunter formations negatives the idea of any great amount of denudation between these two periods in this neighbourhood.

[2] It thus appears that the Magnesian Limestone overlaps its own Marl Slate base, with which it appears to be perfectly conformable. Yet no one supposes there is a "great break" between them. Had, however, this overlap been concealed by a cloak of Lower Bunter, that formation, and not the Magnesian Limestone, would have been credited therewith, and the fact cited as an additional proof of the great break between the Permian and New Red Sandstone periods.

It is with no small gratification that I find so eminent a Government Surveyor as Mr. Aveline is willing to admit that the great break in this district is, as I have laboured in my paper to show, at the bottom and not at the top of the Permians, and that he has become converted to the opinion that the "Lower Red Sandstone" is a myth. E. WILSON.

NOTTINGHAM, *15th April*, 1877.

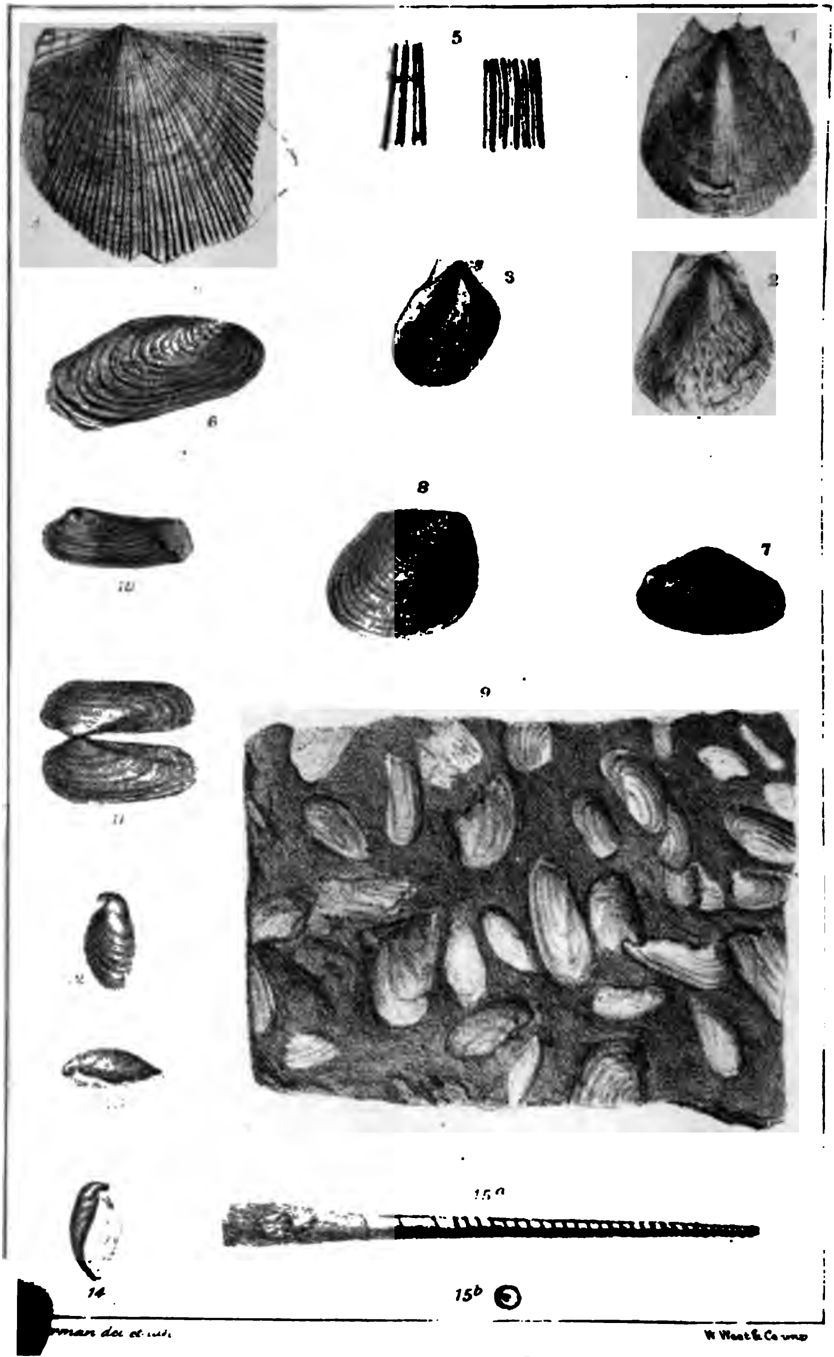
MONOGRAPH ON BRITISH CARBONIFEROUS GANOIDS.

SIR,—Will you kindly permit me, through the medium of your Journal, to correct and apologize for a very awkward blunder, which occurs in the first part of my monograph on British Carboniferous Ganoids, recently published by the Palæontographical Society? In the Introduction I have advocated the retention of the *Dipnoi* as a distinct order of fishes; but at p. 41, in a manner unaccountable to myself, for I certainly did not mean it, I have included them as a suborder of the *Ganoidei*. That this "slip of the pen" was not detected in the revision of the proofs must have been due to an amount of carelessness, of which I am justly ashamed.

April 2. R. H. TRAQUAIR.

CARBONIFEROUS GANOID FISHES.—ERRATA.

Page 7, line 24, *delete* "which."
„ 12 „ 11, *for* "Egerton" *read* "Agassiz."
„ 14 „ 3, *for* "interclavicular" *read* "infraclavicular."
„ 16 „ 28, *insert a* "(" *before* "*Elonichthys*."
„ 28 „ 34, *for* "or" *read* "on."
„ 38 „ 31, *for* "centre" *read* "centra."
„ 41 „ 34, *delete* "Suborder I. Dipnoi."
„ 41 „ 35, *for* "II." *read* "Suborder I."
„ 41 „ 36, *for* "III." *read* "II."
„ 42 „ 4, *for* "IV." *read* "III."
„ 42 „ 5, *for* "V." *read* "IV."



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Mollusca Carboniferous.
Scotland.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE II. VOL. IV.

No. VI.—JUNE, 1877.

ORIGINAL ARTICLES.

I.—FURTHER CONTRIBUTIONS TO BRITISH CARBONIFEROUS PALÆONTOLOGY.

By R. ETHERIDGE, Junior, F.G.S.

(PLATE XII.)

Class LAMELLIBRANCHIATA. Genus PECTEN, Bruguière.

Pecten (*Amussium?*) *Sowerbii*, M'Coy. Plate XII. Figs. 1–3.

IN the GEOLOGICAL MAGAZINE for July, 1874,[1] I gave a description and figures of this species, and also that of a shell I referred with some hesitation to *Aviculopecten ellipticus*, Phillips, closely resembling the forms referred to *P. Sowerbii*, but differing in the form of the ears, which are after the normal type of the *Pectinidæ*, and not connate, with a re-entering angle between them, as in *P. Sowerbii*. In the above description, and in a note succeeding it,[2] I stated that I had seen traces of the characteristic V-striæ of *P. Sowerbii* on the shells referred by me to *A. ellipticus*. I had at the time some doubts in my own mind as to the propriety of the reference of these shells to *A. ellipticus*, Phill., and now, after consideration and examination of a further large series of specimens, I am convinced that the shell I figured as *A. ellipticus* is nothing more than the opposite valve of *P. Sowerbii*, M'Coy; and that I was too hasty in placing it under the name of Phillips's shell. In other words, one valve of *P. Sowerbii* has the ears connate, with a re-entering angle between them, and the shell very frequently showing the V-striæ (Fig. 1); the other has the ears after the usual form, and the shell only occasionally showing the peculiar striæ (Figs. 2 & 3). Both forms are constantly associated together, often to the exclusion of other members of the *Pectinidæ*, and they exhibit several characters in common with one another, such as puckering or shrivelling of the shell, the lateral grooves from the beaks, and the ears, although differing in form, still striated similarly. If a glance is given at one of my former figures,[3] a point I then neglected to draw attention to will become apparent, viz. that there is a decided indication in the ears of the figure that the specimen represents the compressed valves in apposition. My colleague, Mr. W. Hellier Baily, has given a figure[4] of this species which corroborates my reading of the subject. His figure exhibits the simple small ears, and the shell without V-striæ, but having some beautiful colour markings preserved on it. In an interesting paper lately published, "On New and Peculiar Mollusca of the *Pecten*, *Mytilus* and *Arca* Families procured in the 'Valorous' Expedition,"[1] Dr. J. Gwyn Jeffreys, F.R.S., re-defines the genus *Amussium* as follows: "Shell inequivalve, more or less circular, flattened, smooth or variously sculptured, furnished inside with slight ribs, which radiate from the hinge, and are not impressions of outside markings, but are quite irrespective of them."

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[1] Dec. II. Vol. I. p. 300, Pl. XIII. Figs. 1 and 2.

[2] p. 304.

[3] *l.c.* Pl. XIII. Fig. 1.

[4] Figures Char. Brit. Foss., vol. i. pl. 39, fig. 3.

Pecten Sowerbii was referred by Prof. M'Coy in his second description of the shell[2] to the genus *Amussium*, a reference which is considerably strengthened by the inequality which must exist from the peculiar form of the ears in the two valves, and by the more or less circular or oval flattened form. To complete the analogy we only require the interior radiating ribs, which have not yet come under my own observation in this species. There are also certain analogies with the genus *Pseud-amussium*, to which it has been referred by Prof. de Koninck,[3] but even more so with the genus *Entolium*, Meek. I have lately had an opportunity, through the kindness of my friend Dr. Bigsby, F.R.S., of seeing Hayden's *Final Report on the U.S. Geological Survey of Nebraska*, in which Mr. Meek gives a description of *Entolium* (*Pecten*) *aviculatum*, Swallow.[4] The genus *Entolium* was founded by Meek on *Pecten demissus*, Phill., an Oolite shell possessing a very peculiar hinge structure, well figured by Quenstedt. "I am not sure the group," says Mr. Meek, "is more than sub-generically distinct from *Pseud-amussium*, Brug. It differs from *Amussium* mainly in having no internal costæ, and in having the valves more nearly equal, with, sometimes, minute radiating but in my former description of *P. Sowerbii* I noticed a number of fine lines to be seen in the substance of the shell rather than on it, especially when the shell is held at an oblique angle. Through the kindness of Mr. A. Patton I am now able to figure this (Fig. 1). Mr. Meek further remarked on the presence of the V-striæ nearly always on one valve only—a character particularly coinciding with our shell, and adds that the V-striæ are possibly a "sort of effort at internal markings, of a very different kind, but in some respects analogous to the internal costæ of *Amussium*."

Genus AVICULOPECTEN, M'Coy, 1851. (Annals Nat. Hist., vii. p. 171.)

Aviculopecten papyraceus, Sow. Plate XII. Figs. 4 and 5.

Obs.—I give a figure of one of several specimens well preserved in a dark limestone from the English Lower Coal-measures. The extreme variation in the ribbing of the same individual is remarkable. The flattened spaces between the primary ribs or ridges are sometimes plain, or subdivided by one large interpolated rib from the margin, which does not reach the beak, or by two smaller ribs which ultimately unite and become one. In the case of the last-named variation, the two interpolated ribs are separated by a less space than separates each of them from its contiguous primary ribs. The specimens before me are all left valves, and have the anterior ear ornamented with from five to six radiating ribs. The posterior margins of all but one specimen are rounded, and form, with the hinge-line, well-marked but obtuse angles. In the exception the posterior margin is slightly sigmoidally curved, and the posterior wing slightly pointed.

Loc. and Horizon.—Lower Lomax, Bury by Bolton-le-Moor, Lancashire, in a dark limestone of the Lower Coal-measures. *Coll. Mus. Pract. Geol.*, London.

Genus ANTHRACOMYA, Salter, 1861. (Iron Ores of Great Britain; Mems. Geol. Survey, p. 229.)

Anthracomya Phillipsii, Williamson. Plate XII. Figs. 6 and 7.

Unio Phillipsii, Will., 1836: Phil. Mag. vol. ix. p. 351. (Without description.)
Unio linguiformis, Phillips, 1839; Murchison's Silurian System, p. 88.
Modiola sp., Binney, 1855; Mems. Lit. Phil. Soc. Manchester, 2nd ser., vol. xii. p. 221, note. (Without description.)
Anthracomya Phillipsii, Huxley and Etheridge, 1865; Cat. Foss. Mus. Pract. Geol. pp. 157 and 160. (Without description.)
——————— Jones, 1870; GEOL. MAG. Vol. VII. p. 217, Pl. IX. Figs. 3 and 18.

Sp. Chars.—Transversely-obliquely-oval, modioliform, elongated in the direction of the diagonal. Anterior end small, its margin rounded; posterior end much higher than the anterior, with a long obliquely truncated margin, forming by its union with the hinge-line an obtuse angle. Hinge-line straight, almost half the length of the diagonal of the shell; ventral margin convex, becoming straight anteriorly and passing up obliquely to the anterior end, when, if continued to meet the dorsal margin in a direct line, a very acute angle would be formed. Beaks anterior, almost terminal, very obtusely rounded and inconspicuous; in the uncrushed condition there is probably a more or less blunt diagonal ridge. Ornamentation consisting of concentric wrinkles and finer striæ between them: on the anterior end there are traces of a further transverse wrinkling.

Obs.—*A. Phillipsii* was first noticed by Prof. W. C. Williamson, in the second part of his paper "On the Limestones found in the Vicinity of Manchester," as a "*Unio* of small size." He adds: "The shell varies considerably in size, being sometimes one inch and a half in length, and at others not more than three-fourths of an inch. The depressed and crushed state in which these fossils are found would indicate a shell of a thin and fragile nature." The shell was named *Unio Phillipsii* in honour of Dr. C. Phillips of Manchester. In a letter from the late Prof. Phillips quoted by Sir R. I. Murchison in his "Silurian System," this shell is spoken of as *Unio linguiformis*, and a brief description is given. Mr. E. W. Binney, F.R.S., obtained *Anthracomya Phillipsii* in red and greenish mottled clays near the junction of the Coal-measures and New Red Sandstone in the Valley of the River Medlock, near Manchester. He records it under the name of *Modiola* sp., to which genus he considered the uncrushed condition to bear the greatest resemblance. I believe the Catalogue of Fossils in the Museum of Practical Geology to have been the first publication in which *Unio Phillipsii* was referred to the genus *Anthracomya*, probably from a determination of the late Mr. J. W. Salter. Similarly, I think the first, and perhaps only figure of this shell, which has hitherto appeared, is that given by my friend Prof. T. Rupert Jones, F.R.S., in his paper

1868, p. 204, fig. 44. *Anthracomya (Naiadites) lævis*, Salter, Quart. Journ. Geol. Soc., 1863, vol. xix. p. 79, fig. 2. Also *Unio nuciformis*, Hibbert, Trans. R. Soc. Edinb., 1836, vol. xiii. p. 245.)

Sp. Chars.—Obliquely-broad-ovate, flattened, abruptly truncated along the dorsal margin. Anterior end rounded; posterior end produced ventrally, its margin obliquely rounded. Hinge-line not so long as the shell, passing insensibly into the oblique posterior margin. Umbones anterior, but not terminal, inconspicuous. Shell marked with exceedingly close fine microscopic thread-like striæ, with a few transverse wrinkles, which at times give it the appearance of being partially radiately striated.

Obs.—A small shell was described by Dr. Dawson from the Coal-measures of the South Joggings, Nova Scotia, under the name of *Naiadites lævis* (=*Anthracomya*, Salter), to which the present shell bears so strong a resemblance that I was for some time quite at a loss how to distinguish between them. However, *A. Scotica* is larger than the Nova Scotian *Naiadites lævis*. Judging from Dr. Dawson's figure, the concentric striæ are also more numerous, finer and closer; the posterior end appears to be more obliquely truncate, and the beaks are more anterior.

In pointing out the resemblance between these two forms, I am supported by the opinion of Prof. T. Rupert Jones, F.R.S., who, independently of any views of my own, suggested a reference of the Scotch fossil to Dr. Dawson's species. It is sufficiently distinct from the other *Anthracomyæ* and *Naiadites* described by Mr. Salter,[1] and Dr. Dawson,[2] not to require comparison; but it appears to be related to *Anodonta obstipa*, Ludwig.[3] Judging from figures only, *A. Scotica* also resembles the shell figured by Prof. T. R. Jones as the probable young of *Anthracomya Phillipsii*, Will.;[4] but the concentric striæ are much closer and the shell larger, as Prof. Jones's figure is highly magnified. Dr. Hibbert long ago obtained, from strata connected with the Burdiehouse Limestone, a shell to which he gave the name of *Unio nuciformis*.[5] Hibbert's figure represents a shell in the uncrushed state of a particularly convex and globose form. All our efforts to re-discover this shell have failed hitherto; and as Dr. Hibbert's collection was brought to the hammer, I am afraid little chance remains of our ever being able to obtain access to the type, although I have tried all means at my disposal. The thought has often struck me whether this species might not be *Unio nuciformis* in a perfectly flattened form, its usual condition. Although some of the characters bear out this supposition, still, I have seen no evidence in the flattened examples of *A. Scotica* of the great inequality of the valves exhibited by Dr. Hibbert's figure.

Loc. and Horizon.—The figured example is from the Linnhouse Water between Calder Hall and Calder Wood, near Mid Calder,

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[1] Iron Ores, Great Britain, pp. 230–1.

[2] Acadian Geology, 2nd ed., p. 204.

[3] "Freshwater Shells of the Coal-formation of the Urals," *Palæontographica*, vol. x. t. 3, f. 2.

[4] GEOL. MAG., Vol. VII. Pl. IX., Fig. 18.

[5] Trans. R. Soc. Edinb., *vol. xiii. p.* 245.

Edinburghshire. Mr. C. W. Peach has collected *A. Scotica* from shale above the Burdiehouse Limestone at Straiton Oil-shale Mines, near Burdiehouse, and from shale interbedded with trap on Inchkeith Island, Firth of Forth. Mr. J. Bennie has obtained the species at numerous localities in the oil-shale ground to the west of Edinburgh, including Straiton Oil-shale Mine, and I have found it at the first quarry east of the Binn Hill, Burntisland, Fife. It was communicated to me by Mr. J. Linn, from shale obtained at Middleton Pit, Uphall, Edinburghshire. These localities are all in the Cement-stone Group, near the horizon of the Burdiehouse Limestone. Both Mr. J. Henderson (Edinb. Geological Society) and Mr. Bennie have found it sparingly in a lower horizon of the Cement-stone Group than the Burdiehouse Limestone, viz. the Wardie shales, in the Water of Leith, at Kates-mill, near Edinburgh.

Genus SANGUINOLITES, M'Coy, 1844. (Synopsis Carb. Foss. Ireland, p. 47; Brit. Pal. Foss. p. 276.)

Sanguinolites ? *Abdenensis*, sp. nov. ? Plate XII. Figs. 9-11.

Sp. Chars.—Transversely elongated; two and a half times as long as high. Anterior side short, rounded; posterior side produced, margin subtruncate in its upper part, rounded below. Dorsal and ventral margin almost parallel, the former long and straight, the latter with a very little shallow sinus in it a little posterior to the umbones; the latter are anterior. Diagonal ridge faintly marked; posterior slope scarcely defined from the body of the shell. Surface ornamented with concentric lines parallel to the margins, which leave little or no trace on the posterior slope of casts.

in which the shell occurs requires that a name should be given to it, and in the absence of any more definite characters, the above will serve to distinguish it.

Loc. and Horizon.—Covering the surface of a bed of shale discovered by Mr. Bennie, in large numbers, below the Abden Limestone, on the shore between tide-marks, at Abden, a short distance to the east of Kinghorn, near Kirkcaldy, Fife, near the base of the Lower Carboniferous Limestone Group. Collection of the Geol. Survey of Scotland, and my own Cabinet.

Genus CAPULUS, de Montfort. *Capulus neritoides*, Phillips. Plate XII. Figs. 12-14.

Pileopsis neritoides, Phill., 1836; Geol. York., vol. ii. p. 224, t. 14, f. 16-18.
„ *vetustus*, „ (non Sow.) „ „ „ f. 19.
„ *angustus*, „ 1836 „ „ „ f. 20.
Acroculia vetusta, M'Coy (pars), 1844; Synop. Carb. Foss. Ireland, p. 45.
Capulus neritoides, de Koninck, 1842-44; Descr. Anim. Foss. Terr. Carb. Belgique, p. 334, t. 23 *bis*, f. 1.
Acroculia angusta, and *A. neritoides*, Tennant, 1847; Strat. List Brit. Foss. p. 105.
„ „ D'Orbigny, 1849; Prodrome de Pal., p. 125.
Pileopsis neritoides, Brown, 1849; Foss. Conch, p. 102, t. 47, f. 48 and 51.
„ *angustus*, „ „ „ „ „ 103, t. 47, f. 54.
„ *vetustus*, „ „ „ „ „ „ „
Capulus auricularis, M'Coy; Brit. Pal. Foss., p. 523.
„ *angustus*, et *C. neritoides*, Morris, 1854; Cat. Brit. Foss., p. 239.

(Compare *Conchliolithus* [*Helicites*] *auricularis*, Martin, Pet. Derb. 1809, t. 40, f. 3 and 4.)

Obs.—American palæontologists appear to have adopted the name *Platyceras* (Conrad, 1840, =*Acroculia*, Phillips, 1841) for shells similar to the present species, in preference to the earlier proposed *Capulus* (de Montfort, 1810, =*Pileopsis*, Lamk., 1812), in the belief that they are generically distinct from the latter. This separation has been made by Prof. Hall from the absence, in *Platyceras* as he supposed, of the peculiar horseshoe-shaped muscular scar of *Capulus*.[1] Messrs. Meek and Worthen, however, who also adopt the term *Platyceras*, have demonstrated the occurrence of the scar in at least two American species.[2] It follows from this that no satisfactory evidence has, as yet, been adduced for a separation of Conrad's *Platyceras* from Montfort's *Capulus*; but on the contrary the evidence is rather confirmatory of their identity than otherwise.

Prof. M'Coy drew attention to a point which he considered had been greatly lost sight of, the identity of *Conch.* [*Helicites*] *auricularis*, Martin, with *Capulus neritoides*, Phill., and its synonyms. Prof. M'Coy's suggestion appears to be worthy of consideration; for if such is the case, we should, in simple justice to Martin, adopt his name.

I propose to consider the following shell (Plate XII. Figs. 12-14) as a variety of the above species, under the name of

C. neritoides, Phill., var. *Simpsoni*, var. nov.

Varietal Chars.—Shell considerably more depressed than in the typical form; dorsal portion obtusely rounded and wanting the arched character of the latter; distance between the apex and the lower margin is much reduced; the spire has a tendency to become horizontally coiled instead of vertically. The aperture is elongately oval.

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[1] Twelfth Annual Report of the Regents of the Univ. New York, 1859, p. 16.
[2] Illinois Geol. Report, 1868, vol. iii. p. 385.

Obs.—The relation of the variety to the typical form is seen in the pronounced inrolled spire, feebly sinuated sharp edges to the aperture, with an elongated little-marked lobe in front, and the fine concentric striæ, with at intervals a stronger lamina of growth.

The horizontal manner in which the spire is coiled appears to be a peculiar character of this variety. Were it compressed laterally instead of from above downwards, it would be more closely allied to *Capulus* (*Pileopsis*) *compressa*, Goldf., from the Eifel, as figured by Quenstedt.[1]

Loc. and Horizon.—Magazine Limeworks (quarry at), near Pathhead, Haddingtonshire, in shale above No. 2 Limestone (L. Carboniferous Limestone Group). The figured specimen was obtained by, and is in the Cabinet of Mr. J. Simpson, Edinburgh, to whom I am indebted for calling my attention to it, and after whom I name the variety. Specimens are also in the Coll. Geol. Society of Scotland, collected by Mr. J. Bennie.

Genus Dentalium, Linnæus.

Dentalium inornatum, M'Coy? Plate XII. Fig. 1.

D. inornatum, McCoy, 1844; Synopsis Carb. Foss. Ireland, p. 47, t. 5, f. 30.
" " Tennant, 1847; Strat. List Brit. Foss., p. 105.
" " D'Orbigny, 1849; Prodrome de Pal., i. p. 127.
" " Morris, 1854; Cat. Brit. Foss., 2nd ed., p. 246.
" " Pictet, 1855; Traité de Paléontol., vol. iii. p. 303.

Sp. Chars.—Shell slightly curved, very gradually tapering; mouth circular. Surface smooth, without ornamentation (M'Coy).

Obs.—Omitting the question of dissimilarity in size, the only appreciable difference between the specimen and M'Coy's figure is the rate at which they respectively taper. Of the descriptions of smooth Palæozoic *Dentalii* with which I am acquainted, *D. inornatum* appears to be allied to *D. granosum*, var. *lævigatum*, Eichwald,[2] and more especially in minute delicacy to the Permian *D. Speyeri*, Geinitz.[3] A comparison may also be instituted with *D. venustum*, Meek and Worthen;[4] but the latter is a less curved form, and tapers less rapidly. The shelly matter is exceedingly well preserved in our specimen, and not a trace of any ornamentation is to be seen. In the larger of Prof. M'Coy's figures there is a notch or slit in the margin; but as nothing is said about this in the description of the species, I presume it is accidental.

Loc. and Horizon.—"Ardross Limestone," shore (high-water mark) immediately east of Ardross Castle, near Elie, Fife (see remarks under *Orthoceras Brownianum*).

[1] Handbuch, 1852, t. 35, f. 11.
[2] Lethæa Rossica, 1860, i. p. 1062.
[3] Dyas, 1861, p. 57, t. 12, f. 11–13.
[4] Illinois Geol. Report, Palæontology, vol. iii. 1866, p. 284, t. 19, f. 8.

Class CEPHALOPODA. Genus ORTHOCERAS, Breyn.

Orthoceras Brownianun, p. nov. Plate XII. Figs. 15*a* and 15*b*.

tiletto-like Orthoceras, Rev. T. Brown. Trans. R. Soc. Edinb., vol. xxii. pt. 2, p. 362.

(Compare *O. calamus*, de Kon., Descrip. Anim. Foss. Terr. Carb. Belgique, . 506, Supplément, p. 703, pl. 59, f. 2 a-d; *O. regulare*, v. Schl. Sandberger's ie Verstein. d. Rhein. Schichtensystems in Nassau, 1856, p. 173, atlas, pl. 20, 2; *O. planiseptatum*, Sandb. *loc. cit.*, p. 160, atlas, pl. 17, f. 4; *O. acutissimum*, l. *loc. cit.* p. 173, atlas, pl. 20, f. 10.)

Sp. Chars.—Shell much elongated, pointed, and stiletto-like, apering very gradually; section at the smaller end circular (not eterminable at the larger end). Septal sutures distant as compared ith the diameter of the shell, horizontal, not waved; intervals ecreasing very slightly towards the smaller end; septa, as denoted y the only one visible, somewhat flattened, not very convex. hambers as denoted by the intervals between the septal sutures, ith the height (vertical) exceeding the diameter (transverse). iphuncle subcentral. The specimen where septate is a fraction ore than two inches long; the diameter of the smaller end is as ear as possible a little less than half a line; at the upper end nmediately before the point where it is crushed the diameter is bout one line and a half. In the space of one inch there are 19 r 20 chambers. Surface smooth.

Obs.—For an introduction to this elegant *Orthoceras* we are inebted to the Rev. T. Brown, M.A., who aptly termed it in his aper "On the Mountain Limestone and Lower Carboniferous Rocks f the Fifeshire Coast," etc.,[1] the "thin stiletto-like *Orthoceras*," nd mentions it as exceedingly characteristic of his Bed F, or Ardross Limestone," near Elie.

In Prof. de Koninck's classification of Carboniferous *Orthoceratites* is species would clearly come under the division "*Orthocerata racilia*," and in form and slenderness resembles the typical species f that section, *O. Martinianum*, de Kon.,[2] but the septa are rather istant and cannot be described as very close, as in the Professor's ecies. There is a closer resemblance to his *O. calamus;* especially the apical portion represented by Fig. 2*b* on the 59th plate of e "Animaux Fossiles." Our form appears to taper at nearly the me ratio, but is perhaps thinner and more slender; the septal tures are about the same distance apart as those of *O. calamus*, d the section is equally circular, but the siphuncle is subcentral position.

I would also call attention to the resemblance of this Orthoceratite the apical portion of *O. regulare*, v. Schlotheim, as figured by the rs. Sandberger, but in this case the septa certainly appear too far art, and, as in the case of Prof. de Koninck's species, the siphuncle central. *O. Brownianum* is also not unlike the apical portion of . *planiseptatum*, Sandberger, but here the chambers are far too broad r their height to bear close comparison with the present form. In l these cases it must of course be borne in mind that no comparison n be made with the large upper ends in the three species, *O. calaus*, *O. regulare*, and *O. planiseptatum*, especially in the two latter.

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[1] *loc. cit. suprà.*

[2] *op. cit. suprà*, p. 505, t. 44, f. 4.

Prof. M'Coy's description of *O. cylindraceum*, Flem. (non Sow.),[1] with the exception of the waved septa, would almost embrace our species; on the other hand, it does not correspond with Fleming's original figure,[2] or with the specimen from which this was drawn, as I have (through the kindness of Dr. Traquair) ascertained by an inspection of it in the "Fleming Collection," Museum of Science and Art, Edinburgh. Both in *O. cylindraceum*, Flem., and *O. attenuatum*, Flem. (non Sow.), the septa are much more numerous, and the intervals between them relatively too broad for their height.

On the whole, I think we may consider *O. Brownianum* as closely allied to *O. calamus*, de Kon.

Loc. and Horizon.—Bed F, or Ardross Limestone, of the Rev. T. Brown, on shore east of Ardross Castle, near Elie, Fife. This so-called limestone consists of three bands of an impure limestone separated by thin shales, and is well displayed on the beach at high-water mark, at the above locality. The Rev. T. Brown, in his paper before alluded to, speaks of these bands collectively as one, and places it as the lowest of six limestones near the base of what we usually call the Carboniferous Limestone Series. According, however, to Mr. Brown's explanation of the geology of this part of Fife, the Ardross Limestone will be some 1400 ft. above the base of this series, the 1400 ft. in question being taken from the upper part of Mr. Maclaren's Calciferous Sandstone Series (= L. Carboniferous), and tacked on to the hitherto supposed base of the Carboniferous Limestone Series.[3] The Geological Survey Map of this part of Fife[4] by Mr. Howell, represents the patch in which this limestone occurs as Lower Carboniferous (Cement-stone Group). I have much pleasure in naming this *Orthoceras* after the Rev. Mr. Brown, to whom I am indebted for the loan of the figured specimen, and information relating to the Fifeshire coast.

EXPLANATION OF PLATE XII.

Fig. 1.—*Pecten Sowerbii*, M'Coy; nat. size. Cement Stone, L. Carb. Limestone Group. Brewsterland Quarry, E. Kilbride. Cabinet of Mr. A. Patton.

„ 2.—The same; nat. size. L. Carb. Limestone Group, Merry and Cuninghame's Iron and Limestone Pit, near Carluke. Coll. Geol. Survey of Scotland.

„ 3.—The same; nat. size. Shale above No. 1 Limestone, L. Carb. Limestone Group, Whitfield Old Quarry, near Macbiehill Station, Peeblesshire. Coll. Geol. Survey of Scotland.

„ 4.—*Aviculopecten papyraceus*, Sow.; nat. size. Lower Coal-measures, Lancashire. Coll. Mus. Pract. Geology, London.

„ 5.—The same. Various forms of the ribbing, magnified.

„ 6.—*Anthracomya Phillipsii*, Will.; nat. size. Coal-measures, Bradford. Cabinet of E. W. Binney, Esq.

„ 7.—The same; nat. size. Coal-measures, Ardwick. Cabinet of Prof. W. C. Williamson.

„ 8.—*A. Scotica*, R. Eth., jun.; twice nat. size. Cement-stone Group, L. Carboniferous, Mid Calder. Coll. Geol. Survey, Scotland.

„ 9.—Slab showing crushed specimens of *Sanguinolites? Abdenensis*, R. Eth., jun.; nat. size. L. Carb. Limestone Group, Abden, near Kinghorn.

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[1] Brit. Pal. Foss., p. 569.

[2] Annals Phil. 1815, vol. v. p. 202, t. 31, f. 3.

[3] Brown, *l.c.*, p. 391.

[4] Sheet 41, Scotland.

FIG. 10.—*S. Abdenensis*, R. Eth., jun.; left valve, twice nat. size. Same locality.
„ 11.— „ „ „ „ valves partially united along the hinge-line. Same locality.
„ 12.—*Capulus neritoides*, Phill., var. *Simpsoni*, R. Eth., jun.; nat. size side view. L. Carb. Limestone Group, Magazine Quarry, Pathhead, Haddingtonshire. Cabinet of Mr. J. Simpson, Edinburgh.
„ 13.—The same; nat. size, dorsal view.
„ 14.— „ „ view of aperture.
„ 15.—*Orthoceras Brownianum*, R. Eth., jun.; natural size. L. Carboniferous, Ardross, Fife. Cabinet of Rev. T. Brown, Edinburgh. Fig. 15*b*, section enlarged.

II.—ON THE ROCKS OF NEWFOUNDLAND.

By Professor JOHN MILNE, F.G.S.,[1]
Imperial College of Engineering, Tokei, Japan.

With Notes by ALEXANDER MURRAY, F.G.S., of the Geological Survey of Canada, St. John's, Newfoundland.

WHEN we speak of Newfoundland, we speak of England's oldest and yet almost unknown Colony. When we look at its rocks, we shall find that they also are old, and from the metamorphisms and contortions they have suffered are almost unrecognizable. The first geologist who journeyed round the rugged shores which gird the island, and across the marshes and thickets which cover its interior, was the indefatigable Jukes. For two years he laboured hard, and after many dreary tramps up river-courses, across swamps, and round impenetrable scrub, to the shores of quiet inland rocky lakes, he returned without finding a fossil. The next to prosecute research was Richardson, of the Canadian Survey, who fixed a basis of connexion between the geology of the Island and that of the mainland. He was immediately succeeded by Alexander Murray, a veteran geologist, who, in connexion with Sir William Logan, will always be remembered as the earliest worker who successfully unravelled the tangled knots of the Laurentian system. Mr. Murray has been ten years engaged upon this Survey, and has now placed before us a geological map of the greater part of an island about which we previously did not even know the general topographical details, although it was our oldest Colonial possession.

The formations which have been hitherto recognized are shown in juxtaposition with their English and American equivalents in the table on the next page (p. 252).

A mere glance at this table will show the antiquated rocks with which we have to deal, and suggest a picture of all that is weather-worn and grey with age. A distinguished English geologist, Prof. Judd, after inquiring about the age of the rocks in Newfoundland,

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[1] The information contained in the following paper was obtained whilst travelling round and through the island of Newfoundland during the years 1873 and 1874. I visited nearly every bay and cove, and made many journeys into the almost unknown interior whilst twice going round the island. Many specimens, both of rocks and fossils, were collected.

Although I had every opportunity of seeing the island, I must acknowledge the large proportion of material extracted from the early numbers of Mr. Murray's official reports. I also thank Mr. Thomas Davies, F.G.S., of the British Museum, for the microscopic determination of many rocks.—J. M.

[*Table referred to on p.* 251.]

NORTH AMERICA.		GREAT BRITAIN.	NEWFOUNDLAND.
Lower Laurentian		Laurentian	L. Laurentian.
Upper Laurentian			U. Laurentian.
Huronian		*Cambrian ?*	Huronian.
St. John's Group		Lingula Flags	Primordial Silurian.
Paradoxides Slates			
Lower Potsdam			
Upper Potsdam		Tremadoc Slates	Potsdam.
Lower Calciferous			
Upper Calciferous			Calciferous.
Quebec Group	Levis	Llandeilo Beds	Quebec Group: Levis. Lauzon. Sillery.
	Lauzon		
	Sillery		
	Chazy		
Trenton and Bird's Eye Limestones		Caradoc Beds	Bird's Eye Limestone.
Utica Slate			
Hudson River Beds			
Oneida Conglomerate		L. Llandovery Rocks	M. Silurian.
Medina Sandstone			
Clinton Group		U. Llandovery	Clinton.
Niagara Group		Wenlock.	*Niagara ?*
Onondago Group			
Lower Helderberg			
L. Devonian.	Oriskany Sandstone	L. Devonian	*Devonian ?*
	Caudagalli Grit		
	Schoharrie Grit		
	Gaspe Sandstone		Gaspe Sandstones.
Mid. Devonian or Upper Helderberg		M. Devonian	
U. Devonian,	Portage Group, etc.	U. Devonian	
Lower Carboniferous (Gypsiferous)			L. Carboniferous.
Middle Carboniferous (good coal)		Carboniferous	Millstone Grit.
Upper Carboniferous			

and hearing that the newest were Lower Carboniferous, almost shuddered, and wondered how it was possible to live in such a country.[1]

Laurentian.—Commencing with the lowest member of the series, we have a large exposure of crystalline rocks, which have been identified as being of Laurentian age. This identification is based on the relations they hold to the Lower Silurian rocks which they underlie, and on the lithological resemblances they have to the Laurentian rocks of Labrador and Canada. The limestone bands which belong to the Continental exposures of this series have not yet been found; neither have any traces of organic remains.[2] Both in the Northern, Southern, and Central parts of the island we have a great display of these rocks, consisting of granite, syenites, gneiss, etc., together with many igneous dykes, some of which are of considerable breadth. From several of these dykes I collected specimens. One of these from Harbour Deep averages at least 25 yards in width. It cuts through a hornblendic gneiss which is traversed by many small veins of quartz, associated with which are small specks of copper pyrites, especially in the vicinity of the dyke. The rock of which the dyke is composed is a melaphyre of a bluish-green to a black colour, and has a splintery fracture. A specimen from one side of the dyke shows some calcite and a little quartz; a specimen from the opposite side is more compact, and is almost an aphanite. Specimens taken from the inner parts of the dyke were not so compact as those from the exterior, and were of a greyer colour. Crystals of a plagioclase felspar, magnetite, and also a considerable amount of apatite, which latter was not seen in the exterior portion of the dyke, are easily recognized. On going to another portion of the dyke, three-quarters of a mile to the south, and taking a similar series of specimens across its breadth, I found that the exterior portions of the dyke had a more slaty character, and the central part, although it still contained the apatite, also contained quartz, which had not been before observed. This particular dyke therefore illustrates that not only may there be differences at different points across the breadth of a dyke, a result which has often before been observed, but also that we may meet with differences as we work along their length.

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[1] I cannot see upon what grounds Prof. Judd founds this remark. The valley of the Great St. Lawrence, including the magnificent champaign regions of Western Canada, now called Ontario, is based upon Silurian rocks for the greater part, the highest formation being of Devonian age; the beautiful valley of Strathearn, in Perthshire, is upon Old Red Sandstone; the valley of the Forth, Stirlingshire, is Carboniferous; and a great part of Herefordshire, Monmouth, etc., is Lower Silurian. It seems to me, that the capabilities of a country, for the support of life, depend, not upon their actual position in the geological sequence; but upon the constituents of which they are composed, and the mineral character of the debris which is yielded by their ruins, and spread over the surface; and also in great measure to the degree of metamorphism and disturbance by which they have been affected.—A.M.

[2] The crystalline limestone bands of Lower Laurentian age, so well known in Canada, have not been seen *in place*, in Newfoundland; but I have reason to think they

In the vicinity of St. George's Bay there is a series of labradorite rocks which Mr. Murray has recognized as belonging to the Upper Laurentian. I have also seen specimens of labradorite from High Point, River Exploits, but I do not know how it occurs.[1]

Intermediate Series.[2]—The first series we meet with above the Laurentian is a series which is supposed to be the equivalent of the Cambrian and Huronian, to which it has a great lithological re-

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exist to a partial extent in the valley of the great Cordroy River. About thirty miles up that valley I found large angular fragments of white crystalline limestone, with graphite, which exactly resembled the Canadian rocks; and in front of the position they were supposed to occupy the hills are composed of labradorite, which I assume to be of Upper Laurentian age.—A.M.

[1] These are in erratic blocks, more or less water-worn; their source is not known.—A.M.

[2] I object to the term Cambrian, as applied to Huronian, and I introduced the name *Intermediate*, because the system is undoubtedly *intermediate* between the Laurentian and the lowest beds of Primordial strata, holding *Paradoxides*, *Agraulus*, *Archæocyathus*, *Iphidea*, *Agnostus*, *Conocephalites*, *Obolella*, and many other forms typical of the lowest Palæozoic fauna. I have shown that the *Intermediate* or *Huronian* system, must have been worn through by denudation to the very base, previous to the deposition of the beds holding the above-named fauna; as we find them occurring nearly undisturbed overlapping the Laurentian and lower beds of the Huronian. I pointed my evidences out to my old friend and colleague, Sir William Logan, on the ground, who was immediately convinced of the accuracy of my observations. I have also shown that there are some striking lithological resemblances between the *Intermediate* of Newfoundland and the typical Huronian of Canada.—A.M.

semblance. It has been called by Mr. Murray the Intermediate Series. These beds are in the main made up of dark-coloured slates,[1] some of which are fine-grained and cherty, red and grey conglomerates, and various sandstones. There are also some igneous rocks like diorite, quartzite and jaspery bands intercalated in the series.

Considering that there is good reason for believing that these strata are of Huronian age. they are remarkable as containing fossils.[2] The fossils are *Aspidella terranovica,* together with traces of organisms like *Arenicolites.*

At many points in this Huronian Series, which has a great resemblance to the Gold-bearing Series of Nova Scotia, traces of metallic ores have been found. Thus on Terra Nova River an opening has been made on a quartz lode containing copper pyrites, coursing through a chloritic and calcareous rock. A more successful undertaking is, however, to be seen at the La Manche Mine.[3] The ore worked is galena, which is associated with blende, barytes, quartz, amethyst, and calcite, the latter forming the chief portion of the gangue. One side of the lode is bounded by greenstone, or more truly an amygdaloidal melaphyre, in the ground mass of which there is a large quantity of acicular needles of apatite. On the opposite side of the lode we have the black slates of the country, but so hardened that they have the appearance of a siliceous rock.

Primordial Silurian.[4]—Lying unconformably above the Huronian rocks, and distinguished from them by their fossil contents, we have a series of rocks identified by Mr. Murray as the Primordial Silurian, lying as they do at the very base of the Silurian. My last opportunity of seeing these rocks was whilst coasting along the shores of Bonavista Bay, especially in the neighbourhood of Cutler's Head, where they are exposed in cliffs several hundreds of feet in height. The rocks are fine-grained, chloritic, and argillaceous. In many places they are coloured with red oxide of iron. Some of the rocks of this neighbourhood of an amygdaloidal character appeared to be altered diorite.

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[1] The type of the system in Newfoundland is in the peninsula of Avalon, where it occupies an enormous area. There are, besides the clay-slates spoken of here, a great mass of pale-green felsite slates, which weather of a dingy whitish colour, with occasional alternating beds of red slate. I have remarked that, except as intersecting veins, lime is very scarce throughout the series as seen in Avalon, and mica almost or altogether absent.—A.M.

[2] The *Aspidella terranovica* and *Arenicolites* are found in the clay-slates, which are pretty high up in the series. They pass immediately below the sandstones and conglomerates of Signal Hill, which appear to be at the summit.—A.M.

[3] Beautiful hand specimens of various ores of copper have been produced from many parts of the distribution, chiefly from quartz veins; but the extent and quantity of the ore, in no case I have ever known, seemed sufficient to warrant the requisite outlay for opening up a mine. Lead occurs in many localities, usually in calcareous veins. The occurrence so frequently of veins of calcite, in a non-calcareous rock, has induced me to speculate on their derivation; which I conceive possibly may have been from infiltration into the fissures of the older rock, from the calcareous overlying Primordial group, now denuded.

[4] I have a very good collection of these fossils from many parts of the island. The formations are distributed in patches; one of the best developments being in Conception Bay, where the relations to the Laurentian and Huronian are most distinctly exhibited. There are also fine developments in Trinity Bay, in St. Mary's Bay, in Placentia Bay, in Fortune Bay, and on the island of Miguelon, from all which places I have made large collections of fossils. The series is recognized in Bonavista Bay, but not so well developed as at the places named above, and I have not hitherto been able to procure any organic remains from them. The base of the series is usually a conglomerate, passing upwards into a reddish sandstone, over which are a set of slates, which are admirably adapted for roofing slates. Mr. Milne's description applies especially to this latter locality.—A.M.

On the western side of this headland there is a deserted monument of folly in the form of a small quarry, which was vigorously worked upon under the impression that the compact argillaceous-like rock of the cliff was a mass of tin-stone.

Further up the bay conglomerate and more igneous rocks of a chloritic character and rich in kaolinized felspar were observed.

Potsdam and Calciferous.[1]—Still ascending in the series, the next members are those of the Potsdam and Calciferous groups. These are to be seen in the northern and western parts of the island.

The former of these groups consists of dark-coloured slates and conglomerates, containing recognized Potsdam fossils. The series amounts to upwards of 5400 feet in thickness. Penetrating these rocks I found dykes very similar to those I observed before, such as felsites and highly chloritic melaphyres containing quartz.

The Calciferous series, which overlies the Potsdam, is one which presents very different characters to any of the preceding. It is well exposed in the western parts of the island upon the northern side of the Port au Port Peninsula, where it consists of definitely stratified grey limestones rich in fossils,—large *Orthosceri*, Corals and *Maclurea* being very noticeable. These limestones weather into thick columnar forms, divided horizontally by joints, just as if so many huge discs with rounded edges had been piled one above the other.

By the action of the sea and other causes, several caverns have been excavated. Two of these I explored. One was wide and open, and about 70 feet in length; the second, which was narrow and low, was about 130 feet in length. Some of these, on future exploration, may yield remains, beneath the bed of clay with which their floor is covered, which may be of interest in connexion with the study of the modern fauna of the island.

Quebec Group.—At the base of this group we get a vast series of graptolitic shales, amounting to about 4000 feet in thickness. Above these shales we have a large display of serpentines and diorites about 1000 feet in thickness. As these serpentines and diorites, which represent the Lauzon or middle division of the Quebec group, are, from an economical point of view, perhaps the most important series in the island, I will consider them at greater length than I have the others. Their importance lies in the fact of their being repositories of metallic ores, a character which they bear not only in Newfoundland, but in all our transatlantic colonies and the United States.

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[1] The passage upwards from the Paradoxides slates is very well displayed in Conception Bay, where there is no evidence of any want of stratigraphical conformity; but it is difficult to tell in what part of the section the Primordial ceases, and the Potsdam proper begins; a great mass of sandstone occurs at Kelly's Island, and there are alternating sandstones and black shales or slates, which form the largest island in the bay—Bell Island. The whole of these strata hold in greater or less abundance *Cruziana similis*, Billings, *Eophyton Linnæanum*, Torrell, several species of *Lingula*, and other forms which Mr. Billings was disposed to think were of Upper Potsdam type. These strata differ considerably from the beds Mr. Milne quotes, on the north and west sides of the island, which are probably higher measures.—A.M.

In Newfoundland this formation has a considerable development. On the eastern side of the island we see it occupying the valley of Gander River, a great portion of the shores and islands of Notre Dame Bay, and farther to the north in the vicinity of Hare Bay. On the west coast it crops out at many points, as at Cow Harbour, Bonne Bay, Bay of Islands, and Bluff Head. On the south we see it in Despair Bay, and extending northwards up Conne River towards the head waters of the above-mentioned Gander River.

All these districts, with the exception of Gander Valley, I visited, and from various points collected several hundreds of rock and mineral specimens. In the fall of 1874 Gander Valley was explored by my friend Mr. Murray, and to him I am indebted for a collection of rocks from that locality.[1] They consisted of many schists, most of which were more or less chloritic; some were, however, argillaceous and slightly calcareous, whilst a few were harsh and splintery clay-slates. Bands of dolomite are here and there intercalated, some of which contain disseminated particles of magnetic or chromic iron, which by decomposition give a rusty appearance to the weathered surface of the rock.

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[1] I made a very full report upon the Quebec Group in 1874, the result of my own observations in 1873, and of my assistant's survey by my direction in 1874; to which I beg to refer for my views of the structure. At page 52 of the said Report I have expressed myself thus: "The facts ascertained, as already represented in the description of the coast and river sections on the east side of Port-a-Port Bay, seem to point to the conclusion that the Silurian formations are arranged in a series of sharp anticlinal and synclinal folds, ranging generally about N. 22° E., S. 22° W.; the whole mass of strata having, towards the close of the later deposits or subsequently, been affected by vast igneous intrusion, and become much dislocated by great parallel or nearly parallel faults, the ground trend of which is N.E. and S.W. At the summit of the whole series is a great volume of igneous and magnesian rocks, consisting of various diorites, serpentines, and chlorites, which our evidences seem to indicate to be lapped over the inferior strata unconformably, and to come in contact with different members at different places." In Sir William Logan's investigations in Canada, the great mass of sandstone and conglomerate, displayed so largely at Sillery and other parts of the Gulf of St. Lawrence, were provisionally placed at the summit of the Quebec Group, and as overlying the metamorphic and igneous rocks with serpentines and metallic ores, etc.; but our evidences in Newfoundland seem to point to a somewhat different conclusion—unless, indeed, there may happen to be two great sandstone formations, one of which is absent in this island. The description of the rock of the St. Lawrence applies in nearly every particular to the rock here; but while we find it to succeed the Levis formation with perfect regularity, although with numerous folds and twists, in every case it seems to pass *below* the serpentines, wherever a contact has been seen; and moreover to pass below them unconformably. The Long Point of Port-a-Port Bay contains fossils recognized by the late Mr. Billings as *not older* than the Bird's Eye and Black River, and *may be* near the base of the Hudson River Group; and these strata are comparatively undisturbed; but they are brought down by a fault against older rocks, at the base of which the sandstones are displayed in great disturbance. Having weighed all the evidences with great care, I have come to the conclusion that the great igneous intrusion, of which mention is made in the above extract, must be nearly of the age of the Chazy, or perhaps later; that it has been the metamorphosing agent, and that the altered strata consisting of chloritic slates, serpentines, melaphyres, diorites, etc., belong to a horizon somewhere intermediate between the Chazy and the Hudson River Group.—A.M.

A predominating feature among these rocks are dark-green serpentines, which show traces of actinolite, and some specimens could only be regarded as serpentinized varieties of this mineral. Associated with the serpentine, veins of chrysotile are common. A quartz conglomerate and veins of quartz have also been found. The latter are supposed to contain gold, but what the result of their analysis has been I am not yet able to say. On the whole, the rocks have a green chloritic look, and are magnesian in their character.

Further to the north, in Notre Dame Bay,[1] there is quite an archipelago of islands, the greater number of which seem to belong to the Quebec Group. There are amongst them, however, some granites, porphyries, felsites, diorites, and basalts,[2] to which no particular horizon can be assigned. On Pelly's Island, copper pyrites is found, and mining operations have been commenced in rocks which are dark-green in colour and chloritic in character. On Toulinguet we also find a more or less chloritic series of rocks. On the mainland, upon the north side of the Bay, we meet with massive serpentinous rocks. All of this series have, however, been so altered and contorted that it is difficult to make out their lithological characters, and almost impossible to make out their stratigraphical relations. Along the coast these rocks form bold cliffs, here and there broken by small indentations forming small bays and coves. Inland, they form moderately-sized hills, which are covered with drifted boulders.

The serpentines are dark and light green in colour, some are compact and splintery, whilst others are soft and earthy. When jointed, their partings contain either gypsum or calcite. Chrysotile is also to be seen, whilst magnetic iron, and probably also chromic iron, are disseminated through the mass. Enstatite, diallage, and bronzite have also been observed.

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[1] The confusion and disturbance manifested in Notre Dame Bay is such, that to obtain a structural section is almost impossible; while the total absence of organic remains in the group which contains the metallic ores adds to the difficulty of disentangling the complexities. Our evidences of horizon are therefore of a negative rather than a positive kind; but the circumstance of these altered rocks being succeeded by a group containing fossils typical of a horizon ranging between the upper part of the Hudson's River Group and the Clinton is significant. These upper strata have been found in unconformable contact with the older and metal-bearing formations, and traced from the extreme eastern end of New World Island to the Exploits River. Near the base of the group there is a black shale or slate with *Graptolithus ramosus*, which was followed far up the Exploits River. These fossils Mr. Billings supposed to be types of Hudson River age. The higher beds of the formation were found to contain the following fossils, many of which indicate a period as late as the Clinton:—*Orthis ruida; Rhynchonella; Stricklandinia lens; Modiolopsis; Atrypa reticularis; Strophomena rhomboidalis; Leptæna sericea; Orthis Davidsoni* (?); *Heliophyllum; Zaphrentis bellisriata; Petraria; Favosites Gothlandica; Orthoceras Murchisonia; Bronteus; Encrinites;* and *Pentamerus.*—A.M.

[2] In my report for last year, 1876, I have shown reason for believing that the granites here spoken of are later in date, or contemporaneous with, the Quebec Group; and in my report upon the Exploits, 1871, I have shown that the porphyries and some of the basalts intersect the Middle Silurian. Felsites and diorites occur in strata in the Quebec Group; and also as intersecting veins.—A.M.

The chloritic rocks are sometimes slaty in their character, and sometimes compact and earthy. Very often these rocks are talcose, and in their joints calcareous. Grains of magnetite are to be seen in the mass. Some of them give indications of having been derived from diorites. Associated with this series are a number of rocks which are also, but to a much less degree, chloritic. Amongst them we have altered felsites of a light-green colour, some of which show changes approaching serpentine. There are also others of a green colour, which are tolerably compact, but which under the microscope apparently resolve themselves into a volcanic ash or breccia. In some cases the angular and sub-angular fragments of which these rocks are made up are easily to be recognized. Distinct traces of crystals of felspar are also to be made out.

Amongst these rocks, bands or beds of dolomite are occasionally found, associated with which at Tilt Cove there is an irregular deposit of copper-nickel. It is in the form of small strings and nests. With the chloritic rocks irregular deposits of copper pyrites occur; this has led, in the case of Tilt Cove, to the opening of a large and prosperous mine.

Further to the north, at Terra Nova Mine, a similar series of rocks is to be met with. Here the predominating metallic ore is iron pyrites, which occurs in a band about five feet in thickness.

Although sedimentary rocks are exhibited in the district, volcanic rocks nevertheless predominate and give a character to the whole. That in Silurian times we had volcanos of large extent may alone be inferred from the existence of the extensive beds which I have called volcanic ash and breccia. Since that period, however, the rocks have been so changed in character that it is with difficulty, and generally speaking only with the aid of the microscope, that their origin is to be inferred.

Along the north side of Hare Bay we find a compact splintery grey slate, which at many points holds finely disseminated iron pyrites, which is also sometimes in veins. Near the head of the Bay, at How Harbour, true serpentinous rocks rise conspicuously into high hills, which have generally a bare appearance and a characteristic reddish tinge. Some specimens from this locality had a splintery fracture and a fibrous structure. With the ¼″ objective, kaolinized felspar, crystalline grains of hornblende and crystals of magnetic iron were distinctly visible, giving altogether indications of an altered diorite. Other specimens showed a striking likeness to some of those from Gander River Valley, 160 miles to the south.

On the western side of the island, commencing at Bonne Bay, are some very high flat-topped hills, which, from their reddish colour and bare surfaces, are at once to be recognized as being serpentinous. To the south of this, in Lark Harbour, we find rocks belonging to this series of a very undefinable character,—they are rusty, argillaceous, and filled with so many joints that it is difficult to obtain ractured surface. However, when one is obtained, the interior of ı rock is seen to be chloritic.

Still further to the south, about Bluff Head and Louis Hills, we get series of weathered amygdaloidal rocks, which may be defined as laphyres. They have generally an argillaceous smell, and are careous, especially in their joints and amygdules. Under the croscope there can be seen, a finely granular ground mass, a much olinized felspar apparently labradorite, and sometimes a mineral iich brilliantly polarizes, which may be olivine. On the whole, y are like altered dolerites, and all of them have a more or less oritic look. In places disseminated through the mass there is a uminous mineral, and very often specks of native copper. These nerals are chiefly found in the more decomposed portions of the k. Up Louis Brook some true serpentines are to be found, and also lolomite. Comparing these rocks on the west side of the island th those of similar age upon the east, they only seemed to me differ in the degree of alteration which they had undergone. d those upon the west in this way tend to confirm the idea of the canic origin of the greater part of this series, as exposed in Newındland.[1]

Southern and Central Exposures.—In the southern and central posures of this series, about Bay East River, we get serpentines, oritic and talcose slates, felsites and micaceous slates. The rocks the whole having a lithological likeness to the other members of ı same series.

Taking a general review of this formation, as presented to us in ches, some of which are more than 100 miles apart, one cannot t be struck with the great lithological similarity which runs 'oughout the whole. In comparing lists of specimens taken from ferent localities, it is found that some are almost identical. The ks everywhere contain serpentines and chlorites, are magnesian their character, and always contain more or less of some valuable neral matter like ores of copper. Sometimes their nature is at ce to be seen, whilst in other cases it is only with difficulty to be ognized. Everywhere they show traces of having been derived m volcanic rocks, and in all cases the alteration to which they ve been subject is similar, and has only differed in amount. oking at the vast hills which yet remain of these rocks, they appear relics of large and powerful volcanos which were in activity ching out showers of ashes and pouring forth great streams of 'a in Mid-Silurian times.[2]

If this view is a correct one, then there was a period when iescent, dreary Newfoundland was like a modern Iceland. Since ıt time, however, great changes have happened, and processes of degradation have washed away portions of these rocks and divided them in patches; whilst metamorphic action has so changed their character that at times they are hardly to be recognized.

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[1] I have already alluded to the probable age of the igneous rocks, and to the logical position of the serpentines on the west coast of the island.—A.M.

[2] This view is not improbable, but I am inclined to think, from the undisturbed e of the rocks already spoken of at Long Point, Port-a-Port Bay, that the time of itest volcanic activity must have been at an earlier date, probably within the ızy or Trenton periods.—A.M.

Sillery (*St. Julien Sandstones, etc.*)[1]—Above the serpentinous and Magnesian series, which has been estimated by Mr. Murray as having a thickness of from 16 to 1700 feet, there is a large series, chiefly composed of black slates and limestones, approximately 3 to 4000 feet in thickness. In these slates, which are well exposed in the northern parts of the island, I have observed both intrusive and imbedded masses of diorite. They are generally of a dark grey or greyish green colour, and in some cases amygdaloidal, the amygdules being filled with calcite. Under the microscope, altered felspar, hornblende and grains of magnetite are generally to be seen.

In Noddy Bay these shales are serpentinous, and contain imbedded nodular masses, which under the microscope resolve themselves into a serpentinized diorite. True serpentine is also to be met with in the same locality. The intrusive rocks of this district would show that the volcanic action continued after the deposition of the upper part of the Quebec Group.

Niagara and Clinton.[2]—The only display of these rocks which has been hitherto recognized is to be found at the head of White Bay, where we have a series of conglomerate, and slates capped with Limestone, altogether 2800 feet in thickness. Owing to the occurrence of a series of faults, some of which may amount to 1000 feet, there has been difficulty in tracing out the sequence amongst the members of this formation. Traversing these rocks there are several large dykes of melaphyre and felsite. One of these latter. at the S.W. end of Sops Island, appears in columnar masses 40—60 feet in height. They are of a pinkish colour, and have a splintery coarse fracture. Their measurements are about 1 foot in diameter, and 20 feet in length. They have generally from 4 to 6 sides. In places they are curved and slightly divergent. The tops of these prismatic-like columns form acute angles with the sides, instead of being at right angles, as is so generally the case. Between these columns strips of greenstone, which under the microscope resolves itself into a melaphyre, may be seen. These felsites are also to be seen further to the north.

On the S.E. side of the island there is a large dyke, which also appears to be a melaphyre, and probably derived from the alteration of a dolerite. It contains many veins of calcite and quartz, and along one side of it a very fair deposit of galena.

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[1] In the note on page 256 I have already expressed my views regarding the stratigraphical position of these sandstones. I have visited St. Juliens myself, and Mr. James Richardson, of the Geological Survey of Canada, visited the place where the formation is largely displayed, at the north-eastern termination of the island; but a contact with the serpentinous group was not seen in either case; and I hold to the opinion that it is in consequence of the later group being unconformably spread over the older rocks, that the sandstones are not seen at How Harbour or at Pistolet Bay.—A.M.

[2] Rocks of Middle Silurian age have already been referred to, as having a wide spread in Exploits Bay and the southern parts of Notre Dame Bay. The lithological characters, and some few obscure fossils, also seem to indicate that the series, or a portion of it, extends far up the Exploits and the Gander Rivers.—A.M.

Devonian.—In the vicinity of Cape Rouge and Fox we find a series of plant-bearing sandstones, coarse conglomerates, and reddish-green slates, amounting altogether in thickness to about 3700 feet, which have provisionally been called Devonian, and are apparently the equivalents of the Gaspe sandstones.

Carboniferous.—The Carboniferous is the newest rock formation of which Newfoundland yet boasts. It is displayed in two localities, in both of which it rests upon a Laurentian base.[1] One of these is in the central part of the island, in the vicinity of Deer Pond and Grand Pond, and the other is in the S.W. part of the island round St. George's Bay. Its thickness is about 6400 feet, and it resembles in every way the lower portion of the equivalent formation of Nova Scotia and Cape Breton. In going up any of the rivers which run at right angles to the general strike of the beds, they are seen to consist of red sandstones, shales, greyish limestones, gypsum, and conglomerate. The gypsum is presented at many points in masses like huge cliffs of chalk. At many points where its contact with the surrounding rocks is to be observed, it seems to occupy the position of an intrusive rock,[2] those with which it is in contact being contorted, broken, and turned up against its sides, as, for instance, at the mouth of Kippens Brook. The conglomerate contains fragments of rock and pebbles of magnetic iron derived from the Laurentian Series, and pieces of limestone containing fossils which are undoubtedly of Silurian age. Several seams of coal, one of which is 3ft. 6in. in thickness, have been met with, and many others in all probability remain to be discovered.

In this series I did not observe anything which could be called an igneous rock, nor do I know that any have yet been observed. This fact would lead to the conclusion that it was previous to this time that Newfoundland sank into the tranquil state in which it now exists.[3]

Drift.—Above the Carboniferous we have no other formation but a covering of alluvium, which in many parts of the island, from the striated angular stones it contains, shows undoubted evidence of glacial action. In places this Drift contains shells very similar to those which are still living in the surrounding sea. These, in conjunction with terraces, raised beaches, roche pèrche, etc., tend to show that Newfoundland was at no very remote period below the present level of the sea. The surface of the rocks on which the Drift rests is often roundly smoothed and striated, indicating what may have been glacial action. This so-called glacial action I am, however, inclined to think, from what I have seen in Newfoundland and Finland, is more likely to have been produced by Coast-ice acting in a rising area, than by glaciers. (See Geol. Mag., De Vol. III. Nos. 7, 8, 9, July, August, and September, 1876.)

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[1] On the north side of St. George's Bay it rests against Calciferous and Potsdam.

[2] I have tried to account for this phenomenon, which I have repeatedly observed, both in Canada and in Newfoundland, and a suggestion is offered at pp. 18 and 19 of my Report for 1873. The strata of Carboniferous age on the north side of St. George's Bay is almost perfectly flat.—A.M.

[3] Neither have I seen any intrusions of trap in any part of the distribution of the Carboniferous; but the formation is very much disturbed and faulted, both on the south side of St. George's Bay and in the Grand Pond region.—A.M.

Conclusion.—In conclusion I may say that it appears rocks of Newfoundland are exclusively old ones, a charact might be inferred from their metamorphosed and generall up and contorted appearances. Here and there fossils e they are scarce. In all formations up to the Devonian and ferous, which are the youngest excepting the general su covering of Drift, igneous rocks are abundant. During times there were probably large volcanos, which gave vent of lava, and deposited large beds of ashes. But even the also have undergone great changes, and are now only to b nized as chloritic and serpentinous masses—a character of m phism which seems to be common to many of the formatic important point about the serpentinous rocks is that they ha already proved to be the receptacles of mineral wealth. parts of the country there is the strongest evidence to show island has lately emerged from the sea, and during this eleva reasons which have in part been previously expressed, we that Coast-ice was the chief agent in impressing on the coa glaciated character which it now carries—a view which ha quently been strengthened by observations on the coast of Besides the metalliferous wealth of the island, which is in confined to the serpentines of the Middle Quebec Group, m be expected from the Coal-measures. When the value of t formations becomes fully recognized, we may expect to see government stimulated to giving further aid to geologica ration,—explorers will be attracted, the dreary wastes of th unknown interior will be penetrated, and something mor will be learnt about the early history and formation of neglected and oldest colony Newfoundland.[1]

III.—What is a Brachiopod?[2]

By Thomas Davidson, F.R.S., F.G.S., V.P.P.S.

PART III.

(*With a large folding Table.*)

Affinities of the Brachiopoda.

For some years past, the serious attention of several malacologists has been directed to the endeavour to dete

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[1] I refrain from more at present, than to make a few general ren Mr. Milne's conclusions in regard to glacial action, and the rise of tl I shall probably have something to say upon these subjects at a futur think, however, there are evidences to show that there must have beer glacial action, probably intermittent; and that the rock-basins of many o lakes of the interior, and other phenomena at high elevations in the inter the coast, can only be accounted for as the result of such an agency. I that the evidences we have, of the rise of the land in *very* recent times, d an elevation of over a hundred feet *at most* over the present level of the se

My new Geological Map of Newfoundland will probably aid in illust Mr. Milne's and my own remarks. It may be obtained at Mr. Edward 55, Charing Cross.—Alex. Murray.

[2] (*Concluded from the May Number*, p. 208.)

63	*Leptæna*	Dalman	1827	*Strophomenidæ* .....

finities of the Brachiopoda, or the exact position the group should
cupy in the animal kingdom. The Invertebrata have been grouped
to five sub-kingdoms, namely, the *Protozoa, Cœlenterata, Annuloida,*
nulosa, and *Mollusca,* and for many years the Brachiopoda
ve been considered to constitute a separate class in the sub-
ngdom Mollusca, a view still maintained by some distinguished
turalists. Milne-Edwards, some years back, separated the
ollusca into two divisions, *Mollusca* and *Molluscoida*, and into the
st division he placed the *Brachiopoda, Polyzoa,* and *Tunicata,* an
rangement that has been followed by many naturalists. Although
e greater number of zoologists have admitted the close connexion
isting between the *Polyzoa* and *Brachiopoda,* some considerable
ubt has been expressed with respect to the affinities and position
the latter to the *Tunicata.* Moreover, a strenuous effort has been
ade by such excellent observers as Steenstrup, Morse, Kowalevsky,
d Alex. Agassiz to demonstrate that the affinities of the Brachio-
da and Polyzoa are with the worms, and that they should form a
vision, or two divisions, of the Annulosa, and be placed close to
e Annelids.

In his review of Kowalevsky's admirable memoir on the embryo-
gy of *Argiope, Thecidium,* and *Terebratula,* Alex. Agassiz observes:
The close relationship between the Brachiopoda and Bryozoa
olyozoa) cannot be more fully demonstrated than by the beautiful
awings upon plate v. of Kowalevsky's history of *Thecidium.* We
all now have at least a rational explanation of the homologies of
achiopods; and the transition between such types as *Pedicellina* to
embranipora and other incrusting Bryozoa is readily explained from
e embryology of Thecidium. In fact, all incrusting Bryozoa are
ly communities of Brachiopods, the valves of which are continuous
d soldered together, the flat valve forming a united floor, while the
nvex valve does not cover the ventral valve, but leaves an open-
g more or less ornamented for the extension of the Lophophore."

With respect to the *Tunicata* we are reminded by Morse, that
owalevsky, Kupffer, Schultze, and others, assign to them a position
the base of the Vertebrate series, through the affinities of some of
eir forms to *Amphioxus,* as well as their singular embryological
lations to the Vertebrates. Gratiolet states likewise that the Tuni-
ta are in no way related to the Brachiopoda, and Hancock, in 1870,
pressed himself to me as follows, "Of late years I have gradually
clined to the opinion that the Brachiopoda are not so closely re-
ted to the Tunicata as we at one time thought. I am now busily
gaged in working out the Tunicata, and they seem to be very in-
nately connected with the Lamellibranchs. I am disposed to
nsider that there is a considerable hiatus dividing the Tunicata
om the Brachiopoda and the Polyzoa or Bryozoa, and that these
o latter groups alone should be included in the *Molluscoida.* If
erefore Morse can establish his doctrine, it will relieve me of some
tle difficulty, inasmuch, as it will militate against Huxley's view
at the branchial sac of the *Ascidian* is the homologue of the
arynx of the Polyzoa. My idea being that the branchial sac is the

true representative of the gill plaits of the Lamellibranch, and has nothing to do with the pharynx of the Bryozoon. There are some characters of the Brachiopoda that are very puzzling." It is therefore evident that the dismemberment of the Molluscoida must be considered necessary, and that we cannot place the *Brachiopoda* and *Polyzoa* in the same division with the *Tunicata.*

The Brachiopoda have likewise been considered by Gratiolet, and some others, to be allied to the Crustacea. Morse reminds us also that twenty-six or twenty-seven years ago Prof. Steenstrup had not only considered the Brachiopoda as worms, but had placed them near the tubicular annelids.

It would not be possible, in this short paper, to enter into the numerous and elaborate details given by those zoologists in support of their views, and the reader must consequently refer for more ample information to Prof. Morse's several memoirs upon the subject, and especially to the one on "the systematic position of the Brachiopoda" published in the Proceedings of the Boston Society of Natural History, vol. xv., 1873, as well as to Kowalevsky's important memoir published in 1875. This last, however, written in the Russian language, not being accessible to every reader, I cannot do better than reproduce the short review published by A. Agassiz in Silliman's *American Journal of Science and Art* for 1874. "The second memoir of Kowalevsky is a very complete history of the development of Brachiopods, strikingly in accordance with the views of Steenstrup, and of Morse, on the affinities of the Brachiopods with Annelids. The homology between the early embryonic stages of *Argiope* with the known annelid larvæ is most remarkable, and the resemblance between some of the stages of *Argiope* figured by Kowalevsky, and the corresponding stages of growth of the so-called Loven type of development among annelids is complete. The number of segments is less; but otherwise the main structural features show a closeness of agreement which will make it difficult for conchologists hereafter to claim Brachiopods as their special property. The identity in the ulterior mode of growth between the embryo of *Argiope*, and of *Balanoglossus*, in the Tornaria stage, is still more striking; we can follow the changes undergone by *Argiope* while it passes through its Tornaria stage, if we may so call it, and becomes gradually, by a mere modification of the topography of its organs, transformed into a minute pedunculated Brachiopod, differing as far from the Tornaria stage of *Argiope* as the young *Balanoglossus* differs from the free swimming Tornaria. In fact the whole development of *Argiope* is a remarkable combination of Loven's and of Tornaria types of development among worms. His paper also includes the history of a less vermiform type of development, that of *Thecidium*, and of *Terebratula*, in which the observations of Kowalevsky fully agree with the previous well-known memoir of Lacaze-Duthiers on *Thecidium*,[1] and of Morse on *Terebratulina*,[2] and it certainly is a striking proof of the sagacity of Morse to have announced so positively, from the history of the American Brachiopoda alone, the vermiform affinities of the Brachiopods now so conclusively proved by the development of *Argiope* in Kowalevsky's paper."

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[1] Annales des Sciences Naturelles, 4ème série, Zool. vol. xv. 1861.

[2] Memoirs of the Boston Society of Natural History, vol. ii.

No one can doubt that the Brachiopods and Amphitrites possess many important characters in common after perusing the admirable observations upon the subject contained in Prof. Morse's memoir; but, at the same time, as was remarked to me by Prof. Verrill, almost any invertebrate group may be annelidelized by overrating certain points of its affinities; and, it seems to me, that one must not place entire confidence in any classification which is founded to so great an extent on embryological characters. It may turn out, however, that the Brachiopoda *really* constitute a division of the Annelids. The setæ do not appear to be a constant character, and the tendinous peduncle of the Terebratulidæ seems very different from the annulated structure which Morse describes in *Lingula*, and it appears, according to Dr. J. Gwyn Jeffreys, to closely resemble the peduncle of a species of *Anomia* (*A. patelliformis*), *Lingula* being likewise an aberrant form.

Morse does not, however, fail to observe that "in considering the assemblage of remarkable characters in the Brachiopoda, we must recognize in them a truly ancient type. Thus, while we do not find them in all their characters resembling any group of worms, I have endeavoured to show that all their features, to a greater or lesser degree, are shared by one or other of the various groups of the Vermes, with one or two features of the Arthropods."

Morse concludes his elaborate series of observations by stating that he must regard the Brachiopoda as *ancient cephalized Chœtopods*, while *Serpula*, *Amphitrite*, *Sabella*, *Protula*, and others, may be regarded as modern (later) *cephalized Chœtopods.*

Mr. Dall, a distinguished American naturalist, is strongly opposed to the idea of placing the Brachiopoda among the Annelids, and in order that the reader may become acquainted with both sides of the question, we must refer him to Dall's paper in the *American Journal of Science* for 1871. Therein he maintains, after a lengthened comparison between the Annelids and Brachiopoda, that these last are allied to the other groups included in the *Molluscoida*, and through their combined characters to the typical Mollusca. Stoliczka agrees with the conclusions advocated by Dall, and adds, "There cannot be, I think, much doubt as to the true Molluscous character of the Brachiopoda, and their proper classification between the *Anomiidæ* of the Pelecypoda, and the Saccopoda, and the arm-bearing section of the Ciliopoda."[1]

With such contradictory views as have here been briefly announced, it seems still premature to emit a positive opinion with respect to the affinities of the Brachiopoda, notwithstanding the mass of most valuable information so ably contributed to science by Morse, Kowalevsky, Dall, and others. The following observations on the affinities of the Brachiopoda have been kindly communicated to me by Prof. W. King, Sc.D.:—

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[1] Palæontologia Indica, Brachiopoda, vol. iv. 1872.

"The group *Palliobranchiata* embraces forms formed of two types of organization. The absence of an anal vent in the Clistenterata makes them inferior to the aniferous Tretenterates. In determining the affinities of the group first thoughts should be directed to the simplest of these divisions: but a difficulty arises; for, so far as is known, the second and highest division was the first that made its appearance. This, however, may be got over on the supposition that the Tretenterates became degraded into the Clistenterates,—such a metasmotosis is not unknown; for example, the ventless Ophiurids are outcomes of aniferous pluteiform larvæ, and probably a similar metasmotosis takes place in certain ventless asteroids (*Astropecten*, *Luidia*, etc.). Adopting this supposition, the Clistenterates may be dismissed from further consideration. I shall, therefore, regard the Tretenterates as the initial or older type. The Cambrian system is not only the first in which indisputable organic remains occur, but it is the one in which the Palliobranchs make their first appearance, and, as far as is known at present, they appear to be exclusively Tretenterates; the genera, with perhaps one exception[1] (*Orthis Hicksii*), being all more or less related to *Lingula* and *Discina*. Associated with these Cambrian Tretenterata there are remains of organisms belonging to other groups besides the Palliobranchs. According to the doctrine of Chronogenesis, the natural affinities of any group of organisms can only be determined by its structural characters being considered in connexion with those of other groups of contemporaneous (geological) origin,[2] I shall attempt to give a table of the Cambrian fossils of interest in connexion with the present subject, separated into their respective groups, which I have drawn up from Hicks's memoir on the Tremadoc rocks in the neighbourhood of St. Davids, in South Wales:[3]—

Protospongia	Spongida.
Oldhamia	? Hydrozoa.
	? Polyzoa.
Theca	? Pteropoda.
Lingulella, etc.	Palliobranchiata.
Palasterina	Asteridia and Ceptoidia.
Histioderma, *Scolithus*	Annelida.
Paradoxides, *Agnostus*, etc.	Crustacea.

Of these groups the Palliobranchs have often been associated with *Polyzoa*; but lately Morse has endeavoured to show that they are more closely related to one of the others, *Annelida*. There is no doubt he has succeeded in adducing certain points in his favour; but there are so many dissimilarities between the annelids and the palliobranchs that it is scarcely to be expected the polyzoonal alliance will be abandoned by those who have contended for it, especially since the discovery of *Rhabdopleura*, a marine form of Hippocrepian polyzoa.[4] There is another group of organisms, also occurring in Cambrian rocks, which does not appear to have attracted much notice in connexion with the subject in hand—I allude to the *Asteridia*. The late Johannes Müller showed that in the larval state certain star-fishes have their form completely different from what it is in the adult state, changing from bilateral to a radical character. This is especially the case with the larval star-fish (*Bipinnaria asterigera*), which possesses features strongly reminding one of the structure of *Lingula*. It has a large peduncular appendage at the posterior end of the body: it is furnished with a pair of tentaculiferous arms bilaterally arranged, with the tentacles ciliated; its mouth is situated between and at the base of the arms; it has an intestine, which is doubled back on itself, and terminates at one side as an open gut.[5] This seems so very like the general structural plan of *Lingula* that I prefer associating the Tretenterates with the larval star-fish, rather than with the annelids in a similar stage, or the adult forms of polyzoons. The latter seem to be more removed from the Tretenterates than the annelids. Chronogenesis, though it appears to tell equally in favour of Morse's view, may be held as favourable to the Asteridian affinities of the Palliobranchs; for notwithstanding that *Palasterina Ramseyensis* occurs in a higher horizon of the Cambrian system than the annelids of the Longmynds, Hicks mentions, in a note appended to his description of the above species, that Torrell and Linnarsson have described forms of a Star-fish from Swedish rocks, supposed to be of the Harlech or Longmynd group of the Lower Cambrian. Although admitting that the palliobranchs manifest affinities to the annelids, polyzoons, and asterids, I cannot relinquish the idea that they are more closely related to the molluscs. If they do not possess sufficiently distinctive characters entitling them to rank as a more comprehensive division, I would, instead of associating them with any of the first three groups above mentioned, prefer that they retain their old position in the sub-kingdom *Mollusca*, as defined by Cuvier."

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[1] An *Orthis* (possibly a Clistenterate) has been found in the Menevian group, but to whatever division it may belong does not matter, as *Lingulella* occurs at the base of the Cambrians.

[2] See a memoir by Prof. King, entitled, "An Attempt to Classify the Tetrabranchiate Cephalopods." Annals of Natural History, in 1845.

[3] Quart. Journ. Geol. Soc. vol. xxix. 1872.

[4] First described by Prof. Allman (Quart. Journ. Microscopical Science, N. S. vol. ix. p. 57), next Ossian Sars (id. N. S. vol. xiv. p. 1), previously Ray Lankester has published some valuable "Remarks on the Affinities of Rhabdopleura" in the same work, id p. 77.

[5] Joh. Müller, Ueber die Larven und die Metamorphose des Echinoderm, p. 22, Taf. 2, fig. 1, 1849.

I am, however, quite of opinion that, whether the Brachiopods be placed in a separate group close to the Mollusca, or to the Annelids, they possess sufficient characters of their own to constitute a well-defined class.

DISTRIBUTION IN TIME.

Assuming that the reader is acquainted with the geological divisions into which the crust of this earth has been grouped, I may at once observe, as justly remarked by Barrande, in his admirable memoir, "Epreuves des Théories Paléontologiques par la realité," that the Brachiopoda, after the Trilobites, occupy the most important place in the Cambrian or Primordial fauna. Thus in 1871, out of 241 species known to him as composing the animal kingdom of that period, 179 are referable to the Trilobites and other Crustaceans, 28 to the Brachiopoda, while 34 species would be divided between the Annelides, Pteropodes, Gasteropoda, Bryozoa, Cystidians, and Spongida. Subsequent to these researches several additional species of Trilobites and Brachiopoda have been added to the list through the indefatigable exertions of Prof. Linnarsson, Mr. Hicks, and others. If therefore we exclude the problematical "Eozoon Canadense" from the animal creation, as some naturalists have done,[1] we find the Brachiopoda along with the groups mentioned by Barrande as the earliest representatives of life at present known; for Mr. Hicks has obtained undoubted examples of *Lingula* or *Lingulella* (*L. primæva*) from the very base of the whole Cambrian series of St. Davids in Wales.

It is impossible, for the present, to offer more than an approximate comparison, based on numbers, of the genera and species that have existed during the various and more or less extended geological, periods; and many years will have to pass away before some master minds will be able to grapple with the accumulated observations of a century or more, and reduce the number of genera and species within reasonable limits, from which something like trustworthy data may be formed. Much, indeed, of the confusion must be attributed to the imperfection of the information still existing on zoology and comparative anatomy, so essential to the proper understanding of fossil, or extinct genera and species.

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[1] Dawson, Carpenter, Rupert Jones, and others, consider *Eozoon* to be a Rhizopod or Foraminifer; while King, Rowney, Carter, and others, firmly maintain that it is a mineral production.

But to return to our subject. I cannot do better than to extract from Lyell the following passage. "Nothing is more remarkable, in the Silurian strata generally of all countries, than the preponderance of the Brachiopoda over other forms of Mollusca. Their proportional numbers can by no means be explained by supposing them to have inhabited seas of great depth, for the contrast between the palæozoic and the present state of things has not been essentially altered by the late discoveries made in our deep-sea dredgings. We find the living Brachiopoda so rare as to form about one forty-fourth of the whole bivalve fauna, whereas in the Lower Silurian rocks, and where the Brachiopoda reach their maximum, they are represented by more than twice as many species as the Lamellibranchiate bivalves. There may, indeed, be said to be a continuous decrease of the proportional number of this lower tribe of Mollusca as we proceed from the older to the newer rocks."

Dr. Bigsby informs me that from a conspectus in his new Thesaurus (now in the press) the following numbers of Silurian, Devonian, and Carboniferous Brachiopoda have been given, with due regard to accuracy, but that after all it is only a careful approximation liable to future disturbances:

	America.	Europe, etc.	Total.
Cambrian and Silurian	689	733	1422
Devonian	577	789	1366
Carboniferous	488	384	871
	1754	1905	3659

The number from the Permian formation, which completes the Palæozoic series, has not yet been computed, but they are comparatively few in number. Making a large allowance for synonyms, it will be seen that fully 3000 species are already known to have existed during the primary periods. It is also a remarkable fact that the Brachiopoda, so immensely abundant during the Cambrian, Silurian, Devonian, and Carboniferous periods, became apparently very much less numerous during the Permian and Triassic; while they again became abundant, although comparatively reduced in number, during the Jurassic and Cretaceous period. In the Tertiaries they had materially decreased in number, and are represented, at the present time, by about one hundred species. It has also been clearly ascertained that a certain number of genera and species passed from one system or formation into the one that followed it, as may be seen by a glance at the Table, in which the general distribution of the genera in time has been given with as much accuracy as the present state of our knowledge will admit. From this table it will be perceived that about 9 genera appeared for the first time in the Cambrian system, 52 in the Silurian, 21 in the Devonian, 7 Carbonous, 2 Permian, 2 Triassic, 11 Jurassic, 5 Cretaceous, 3 Tertiary, 9 in the recent periods.[1] But what wonderful changes have n operating during the incalculable number of ages in which the ation (?) and extinction of a large number of genera and thousands species have taken place. Some few only of the primordial, or t created genera, such as *Lingula*, *Discina*, and *Crania*, have fought ir way and struggled for existence through the entire sequence of logical time. Many were destined to a comparatively ephemeral stence, while others had a greater or lesser prolongation of re- duction. These remarks lead me to give some extracts from a er which I received from Darwin as far back as the 26th of April, 1. In that letter, this eminent and admirable observer writes, do not know whether you have read my 'Origin of Species.' In t book I have made the remark, which I apprehend will be versally admitted, that as a whole, the fauna of any formation is ermediate in character between that of the formation above and ow. But several really good judges have remarked to me how irable it would be that this should be exemplified and worked out in e detail, and with some single group of beings. Now every one ll admit that no one in the world could do this better than you h Brachiopods. The result might turn out very unfavourable to views which I hold; if so, so much the better for those who are osed to me. But I am inclined to suspect that on the whole it uld be favourable to the notion of descent with modification. I hardly doubt that many curious points would occur to any one roughly instructed in the subject, who could consider a group of ngs under the point of view of descent with modification. All se forms which have come down from an ancient period very htly modified ought, I think, to be omitted; and those forms ne considered which have undergone considerable change at each cessive epoch. My fear is whether the Brachiopoda have changed ugh. The absolute amount of difference of the forms in such ups at the opposite extremes of time ought to be considered, and w far the early forms are intermediate in character between those ich appeared much later in time. The antiquity of a group is not lly diminished, as some seem to think, because it has transmitted he present day closely allied forms. Another point is how far the cession of each genus is unbroken from the first time it appeared its extinction, with due allowance made for formations poor in sils. I cannot but think that an important essay (far more im- tant than a hundred literary reviews), might be written by one e yourself, and without very great labour."

n several subsequently written letters, Darwin reiterates his gestions. I can assure you that I have not neglected a request ning from so eminent a quarter, but I am bound to state that I e found the subject beset with so many apparently inexplicable ficulties, that year after year has passed away without being able trace the descent with modification among the Brachiopoda which Darwinian doctrine requires.

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[1] These numbers must of course be considered provisional, see Table.

The imperfection (one due, I believe, to our slight acquaintance with the subject) in the geological record cannot in many cases be doubted, but we have no right to make capital out of unknown data. We must therefore deal with facts as we find them, and see how far they will bear upon the subject under examination. It may be quite true, that strata at great distances cannot be positively asserted to be strictly speaking absolutely contemporaneous, although they may contain the same animals.

Prof. Huxley has stated that for anything that Geology and Palæontology are able to show to the contrary, a Devonian Flora in the British Islands may have been contemporaneous with a Carboniferous Flora and Fauna in Africa; but as we have no certainty that such has been the case, it cannot be adduced in support of the theory under notice. It is likewise very probable that some species may have migrated from the sea-bottom on which they originally lived to some more favourable locality, and have become to some extent modified. No one can seriously doubt that life has continued to be represented under one form or another ever since it was first brought into existence, and I consequently cannot agree with M. Deshayes and others who believe in a total extinction of the animal creation at certain specified periods. We are also aware that, taking, for instance, the rocks of the Carboniferous period, in almost every locality in Europe, Spitzbergen, Newfoundland, America, India, or Australia, there are present a few species common to all, in addition to a number that are special to the locality. Thus, for example, as I have shown elsewhere, *Spirifer lineatus* is one of those persistent forms, but with different proportions according to the locality, caused, no doubt, from the sea-bottom being more or less favourable to its development. It is consequently very large in the Punjab, of moderate dimensions in Europe, and considerably dwarfed in Nova Scotia. Still the species remain essentially the same.[1]

Notwithstanding the theoretical doctrine that has been promulgated with respect to the origin of species, we are still and shall probably for ever remain in the dark, or within the region of suppositions, with respect to so important a question. In his admirable address to the Belfast Meeting of the British Association, Tyndall observes: "If you ask me whether there exists the least evidence to prove that any form of life can be developed out of matter, without demonstrable antecedent life, my reply is that evidence considered perfectly conclusive by many has been adduced; and that were some of us who have pondered this question to follow a very common example, and accept testimony because it falls in with our belief, we also should eagerly close with the evidence referred to. But there is in the true man of science a wish stronger than the wish to have his beliefs upheld; namely, the wish to have them true. And this

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[1] It has been observed by Robert MacAndrew that although the size attained by Mollusca (and no doubt by other animals) may be influenced by various conditions in different localities, as a general rule each species attains its greatest size, as well as its greatest number, in the latitudes best suited to its general development; and that whether a species be Arctic, Boreal, Celtic, or Lusitanian, it will grow largest in the region to which it belongs.

ger wish causes him to reject the most plausible support, if he
eason to suspect that it is vitiated by error. Those to whom I
as having studied this question, believing the evidence offered
vour of 'spontaneous generation' to be thus vitiated, cannot
t it. They know full well that the chemist now prepares from
ganic matter a vast array of substances which were some time
regarded as the sole products of vitality. They are intimately
ainted with the structural power of matter as evidenced in the
omena of crystallization. They can justify scientifically their
f in its potency, under the proper conditions, to produce organ-
. But in reply to your question they will frankly admit their
ility to point to any satisfactory experimental proof that life can
eveloped save from demonstrable antecedent life." Further on
dds, "In fact, the whole process of evolution is the manifesta-
of a Power absolutely inscrutable to the intellect of man."

arwin's tempting and beautiful theory of descent with modifica-
bears a charm that appears to be almost irresistible, and I would
he last person to assert that it may not represent the actual
e of specific development. It is a far more exalted conception
. the idea of constant independent creations; but we are stopped
, number of questions that seem to plunge the conception in a
e of inexplicable, nay, mysterious difficulties; nor has Darwin,
r as I am aware, said how he supposes the first primordial form
ave been introduced. The theory is at best, as far as we can at
ent perceive, with our imperfect state of knowledge, but half
truth, being well enough in many cases as between species and
ies; for it is evident that many so-termed species may be nothing
e than modifications produced by descent. It applies, likewise,
cidental variations as between closely allied genera, yet there is
h more than this, with respect to which the theory seems in-
cient. The strange geological persistency of certain types, such
f *Lingula*, *Discina*, *Nautilus*, etc., seems also to bar the at present
ough acceptance of such a theory of general descent with
ification. Barrande seems to be strongly opposed to the
winian view, for in his admirable memoir already quoted he
es: "Par contraste nous devons constater, comme resultat final
os études, que l'observation directe contredit radicalement toutes
prévisions des théories paléontologiques au sujet de la com-
tion des premières phases de la faune primordiale Silurienne.
effet, l'étude speciale de chacun des éléments zoologiques qui
stituent ces phases, nous a démontré, que les prévisions théoriques
en compléte discordance avec les faits observés par la paléon-
gie. Ces discordances sont si nombreuses, et si prononcées que
omposition de la faune réelle semblérait avoir été calculée a dessin,
r contredire tout ce que nous enseigne les théories, sur la pre-
re apparition et sur l'evolution primitives des formes de la vie
nale sur le globe."

Ve have no positive evidence of those modifications which the
ory involves, for types appear on the whole to be permanent
long as they continue, and when a genus disappears there

is no modification, that I can see, of any of the forms that continue beyond, as far as the Brachiopoda appear to be concerned, and why should a number of genera, such as *Lingula, Discina, Crania,* and *Rhynchonella,* have continued to be represented with the same characters and often with but small modification in shape during the entire sequence of geological strata? Why did they not offer modifications or alter during those incalculable ages? Limiting myself to the Brachiopoda, let us see what further they will tell us upon this question. Taking the present state of our knowledge as a guide, but admitting, at the same time, that any day our conclusions and inductions may require to be modified by fresh discoveries, let us ascertain whether they reveal anything to support Darwinian ideas. We find that the larger number of genera made their first appearance during the Palæozoic periods, and since they have been decreasing in number to the present period. We will leave out of question the species, for they vary so little that it is often very difficult to trace really good distinctive characters between them; it is different with the genera, as they are, or should be, founded on much greater and more permanent distinctions. Thus, for example, the family *Spiriferidæ* includes genera which are all characterized by a calcified spiral lamina for the support of the brachial appendages; and however varied these may be, they always retain the distinctive characters of the group from their first appearance to their extinction. The Brachiopodist labours under the difficulties of not being able to determine what are the simplest, or which are the highest families into which either of the two great groups of his favourite class is divided; so far then he is unable to point out any evidence favouring progressive development in it. But, confining himself to species, he sees often before him great varietal changes, so much so, as to make it difficult for him to define the species; and it leads him to the belief that such groups were not of independent origin, as was universally thought before Darwin published his great work on the Origin of Species. But in this respect the Brachiopoda reveal nothing more than other groups of the organic kingdoms.

It would appear that the earliest forms among the Brachiopoda are referable to the division *Tretenterata*, which includes the genera *Lingulella, Lingula, Discina*, and *Obolella*. Of these only *Lingula* and *Discina* have lived on with but slight modifications in external shape during the entire sequence of geological time; and they are still represented by several species. But in rocks somewhat later in age (from the middle beds of the Menevian group or Lower Lingula flags) to those in which the above genera are found, there occurs a species of *Orthis* (*O. Hicksii*), which may possibly be the first representative, as far as we are aware, of the division *Clistenterata*. On this point, however, I would refer to Professor King's note previously given. Since the Cambrian period both divisions continue to be represented without apparently showing a tendency to pass one into the other. Now although certain genera, such as *Terebratula, Rhynchonella, Crania*, and *Discina*, have enjoyed a very considerable geological existence, there are genera, such as *Stringocephalus, Uncites,* *Porambonites*, *Koninckina*, and several others, which made their appearance very suddenly and without any warning; after a while they disappeared in a similar abrupt manner, having enjoyed a comparatively short existence. They are all possessed of such marked and distinctive internal characters that we cannot trace between them and associated or synchronous genera any evidence of their being either modifications of one or the other, or of being the result of descent with modification. Therefore, although far from denying the possibility or probability of the correctness of the Darwinian theory, I could not conscientiously affirm that the Brachiopoda, as far as I am at present acquainted with them, would be of much service in proving it. The subject is worthy of the continued and serious attention of every well-informed man of science. The sublime Creator of the Universe has bestowed on him a thinking mind; therefore all that can be discovered is legitimate. Science has this advantage, that it is continually on the advance, and is ever ready to correct its errors when fresh light or new discoveries make such necessary.

The importance of the study of the Brachiopoda must be obvious to all. They are among the first well-known indications of life in this world; and they have continued to be very extensively represented up to the present time. They are also very characteristic fossils, by which rocks at great distances, whether in New Zealand or Spitzbergen, in the Himalayas or the Andes, can be identified without its being even necessary for the palæontologist to visit the district from whence the fossils are derived. They are, as Mantell would have termed them, sure medals of creation, the date of their appearance firmly stamped upon them, and their distinctive characters so legibly impressed as to defy misinterpretation.

IV.—ON MR. HELLAND'S THEORY OF THE FORMATION OF CIRQUES.

By the Rev. T. G. BONNEY, M.A., F.G.S.;
Fellow, and late Tutor, of St. John's College, Cambridge.

IN the Quarterly Journal of the Geological Society (vol. xxxiii. p. 142) is an important paper by Mr. Helland, on Fjords, Lakes, and Cirques in Norway and Greenland. In this he notices a theory of mine on the formation of cirques which was published in the same journal (vol. xxvii. p. 312). As I mentioned in a note attached to his paper, he somewhat misunderstands me, supposing apparently that I describe only cirques of a small size,—the fact being, that, so far as I know, the Alpine cirques are quite commensurate with those of Norway. This, however, is of slight importance. My present purpose is to give reasons why, after further observations in the Alps and Pyrenees, and even in the British Isles, I still prefer the explanation then advanced, that the cirques are mainly produced by the combined erosive action of streamlets, to the one given by Mr. Helland, that a cirque is a result of glacial action.

I must first remark that in the Alps the persistency in direction which he observes in the Norway and Greenland cirques, is not maintained. Of those which I described, some indeed look N.; but the Creux de Champs and Fer à Cheval have a N.W. aspect, the former perhaps rather W.N.W.; the Cirque Am Ende der Welt looks S.W., and the two under the Rothstock almost due S. I am, therefore, disposed to regard the fact which he notices as quite independent of any general theory of the formation of cirques.

He further points out that there is a connexion between the position of cirques and the height of the snow-line; and that cirques and glaciers are commonly associated. Hence he concludes that the cirques were excavated by the glaciers, and describes the mode in which he conceives this to have been effected. There is, no doubt, some connexion between the level of the snow-line and of the bed of the cirque. In the Alps, however, the bed of the more important cirques is generally far below the former. (Professor Gastaldi's statement I think places the lower limit rather too high.) Most of those which I describe have their floors about 4500′ to 6000′ above the sea-level; but I have also seen them much higher. The relation, however, in no way militates against my view, because, when the walls of the cirque rise up beyond the snow-line, the conditions most favourable to stream erosion prevail, as a perennial supply of snow rests on the higher ledges and slopes; in fact, I think it would be difficult for a large cirque to be formed, unless the streams were supplied by snow-beds. Again, as to the connexion between cirques and glaciers. Mr. Helland says, "Where the mountains are higher and isolated glaciers are very numerous, cirques are also numerous; and as isolated glaciers are here capable of being formed and maintained at an inconsiderable height above the sea, the cirques also occur at but slight elevations." As I have just observed, proximity to the snow-line is undoubtedly favourable to the formation of cirques, and I quite agree that the above association is one of cause and effect, only that which Mr. Helland deems cause I consider effect —no doubt a rather important difference. I believe that isolated glaciers abound where cirques abound, because a cirque with its sheltered recesses is peculiarly favourable to the formation of a glacier. This connexion seems to me no more to prove his case than the occurrence of a puddle in the sheltered corner of a quarry proves that the water excavated it.

I proceed then to offer reasons why I consider Mr. Helland's theory of the formation of cirques inadequate. It is thus stated— "As the temperature around the glaciers constantly varies about the freezing-point, the incessant freezing and thawing of the water in the cracks in the rock may split it, and the glacier may do the work of transportation for the fragments thus broken loose. On examining the interior of an empty cirque, we observe that a bursting, not a scooping out of the rock has taken place." If I understand him rightly, he regards the cirque as formed by a sort of process of perpetual "tooth drawing."—the bed or slope of the mountain beneath the glacier is cracked by changes of temperature, the fragments are caught by the superjacent ice, lifted up, perhaps wrenched out, and [redacted]orne away. Now with regard to this theory, I must remark in *limine* that I cannot admit a *necessary* connexion between cirques and glaciers, because I see no possibility of drawing any hard and fast line between cirques, corries, and even the ordinary bowl-shaped heads of valleys so common in any country which has been subjected to meteoric action. The small passes into the large, the slope steepens into the precipice; but rain rills before they gather into a streamlet, streamlets before they gather into a river, all produce the same result; viz. a bowl-like excavation in the mountain-side, which is drained by the one outlet valley. I have even seen cirques on clayey banks, in miniature, with walls that might almost be measured by inches. Connecting links may be found, through corrie and cwm, between the merest bowl-like hollow on some down of Chalk or Oolite or even some plateau of sandy clay, and the grandest cirque of the Alps or Pyrenees. The differences are due to the nature of the materials and to other local circumstances.

Besides the above, the following objections seem to me to make Mr. Helland's hypothesis untenable.

1. The general smoothness of the rock in the bed of cirques and corries. Where I have seen the live rock in the bed of a cirque or corrie, it is usually smooth and iceworn. Were it formed as Mr. Helland supposes, it should be always rough,—pitted with the sockets of the extracted rocky teeth,—because it is deepened, not by the wearing away of prominences, but by the fracture of fragments. The sharp-edged blocks of which he speaks, so far as I have seen them, are generally loose and strewn over the basin, *i.e.* they have either fallen directly from above or been dropped by the melting glacier.

2. His theory fails satisfactorily to account for the tarns in certain cirques when they are true rock-basins. "It does not seem likely that they were mainly scooped out like the great lakes, along the sides of which we see groovings and *roches moutonnées* one beside the other; for in the little lakes one often sees sharp-edged blocks covering the bottom. When the glaciers of the cirques filled these small lakes so as to leave but little water, it seems probable that the water thus left would freeze in winter, so that the whole tarn would be frozen to the bottom, and the rocks in that way broken loose. Whatever may be the manner in which these blocks are broken out, we see that, from their situation and form, a bursting has taken place in these tarns, so that they are the last works of the glaciers in the cirques." I quite agree with the final clause; but think that the rest—that the existence of the tarn before its basin—is rather like "seeing the roads before they were made." These tarns are in fact among the basins which I readily concede to glacier action, because, if a small glacier forms in a previously existing corrie or cirque, the descent of the ice from the steep surrounding slopes on to the level floor will facilitate erosion; so this is just where I should expect to find—and commonly do find—a basin; but I have seen true cirques without tarns. The floors also of these basins, as stated above, where visible, are smooth and iceworn. Further, as these basins appear to be sometimes of considerable

depth, how are the excavated materials removed? When there is much pressure from the ice behind, that in front may be forced uphill for a short distance, and a sort of scooping action maintained; but I fail to see how this could happen with Mr. Helland's theory.

3. The size of some of the cirques appears to me also a fatal objection. The walls of the cirques in the Alps and Pyrenees, like those described by him, are often 2000′ or 3000′ high. Indeed one might almost call those of the Creux de Champs double that; for the precipices (as I well know) rise with inaccessible steepness, interrupted by mere ledges, from the floor of the cirque to the very crest of the Diablerets. Does Mr. Helland seriously mean to say that "a small isolated glacier" has settled almost vertically downwards on the site of this cirque, deepening its bed by a thousand yards,—and that too beneath its névé, where the erosive power is weakest?

I am content to ask any one to replace the material removed from one of these great cirques, to clap a glacier on some accidental hollow on the mountain, and then to consider if the problem proposed is mechanically possible. We should want the "rotatory glaciers—whirlpools of ecstatic ice—like whirling dervishes," which Mr. Ruskin long ago suggested, to perform work like this.

4. But suppose for one moment we are not staggered by this feat of excavation. Suppose we imagine a thousand yards of rock dug almost vertically out of the mountain-side. Are we not then forced to admit one of the following alternatives? If this energetic glacier was limited to the immediate vicinity of the cirque, then the floor of this part of the valley ought to be lower than that further down; in other words, there should always be a deep lake beneath the walls of the cirque (which there is not): or else the valley must have been immensely deepened and modified, almost excavated, by the glacier. It is this latter alternative which I understand Mr. Helland to accept; it is this which in my first paper I endeavoured to show was inevitable; and it is exactly this which is not only unsupported but even opposed by the evidence of the Alps and of every mountain region which I have seen. As I have endeavoured again and again to show in arguing against the application of the theory of glacial excavation to the greater Alpine lakes, we have in the valleys little or no indication of any but the most superficial effects of glacial erosion. These valleys commonly have the characteristic forms of river action. In the Val Sesia, Val Bregaglia, in the valley of the Dranse and many more, I have traced glacial marks almost down to the present torrent bed, where the valley itself exhibits the most characteristic forms of fluviatile erosion. The contours also of the valley below Gavarnie are those of river, not of glacial erosion. If then the erosive effect of glaciers is so slight that it is difficult to credit them with the greater Alpine lakes, how can we attribute to them cirques, which occur just at the point where they are feeblest, where the connexion with the formation of the whole valley is most inseparable?

Lastly, Mr. Helland objects to my theory "that the part of the crest surrounding the cirque, and sloping to it, is only some mètres broad, so that it cannot feed even a very small stream." But in all the cirques that I have seen there *are* the streams. In Gavarnie, the Fer à Cheval—all that I have described, and many more besides, the streams are so marked a feature, that even the passing traveller cannot fail to notice them. Sometimes they are supplied by ledges, which, though almost invisible from below, are large enough to support permanent snow-beds; for instance on such a precipice as that of the Creux de Champs, a bed as broad as Regent Street would from below seem a mere streak. Sometimes they may be fed by springs; sometimes it may be that the work of erosion is coming to a standstill for want of a sufficient feeding ground, and the streams are supplied only by the rain drainage of the cliff itself. More than once it has been rather a puzzle to me how those which I saw were supplied. But be this as it may, I have never yet seen a cirque without abundant streamlets; evidenced by the gulleys and water stains in some places, by the actual runlets in others, and by the talus heaps below all. Hence I conclude that the theory of water excavation as applied to all cases, big and little, in hot countries as well as cold—so far as my experience goes—is better than that of ice excavation, which seems mechanically almost impossible, and leads us to conclusions about the formation of valleys which I think most physiographers will admit to be untenable.

V.—ON BARON C. VON ETTINGSHAUSEN'S THEORY OF THE DEVELOPMENT OF VEGETATION ON THE EARTH.

By J. STARKIE GARDNER, F.G.S.

II. The Tertiary Elements of the European Flora.

[Aus dem LXIX. Bande der Sitzb. der k. Akad. der Wissensch. I. Abth. März-Heft, Jahrg. 1874.]

THE following is an abstract of another of the papers forwarded to me from Graz, to which I alluded in the April Number of the GEOLOGICAL MAGAZINE. The author first states that the opinion he had formed, that all the Floras of the present time were represented in the Tertiary Flora of Europe, has been still more confirmed by later researches, and then enters upon his more immediate subject.

Of all the groups of plants comprised in our Tertiary Floras, those which resemble the AUSTRALIAN forms are the most striking and deserve our first attention, as their peculiar and unmistakable characters show more than those of any other group, how a Flora, now completely exotic and distinct, was once fully represented in all its more important elements, in Europe. The Tertiary strata of Europe contain all the characteristic families of the present Australian Flora, represented by many distinctive genera; thirteen families only, and these of small extent, not being hitherto found. The leaves of Australian plants are very characteristic and easily recognized; and there exist, as well as leaves, either fossil fruits, or seeds of the Proteaceæ, belonging to the genera *Banksia*, *Dryandra*, *Hakea*, *Persoonia* and *Lomatia*, and *Petrophiloides* (of the latter the fruit only being known). Besides Proteaceæ, other not less distinctive plants are known, about the determination of which there can be no doubt; these are branches and seeds of *Casuarina* and *Exocarpus*, branches of *Leptomeria*, fruit of *Dodonæa* and *Pittosporum*. In addition to these, twenty-seven other genera are enumerated, and a further list of ten genera resembling Australian forms; but the determination of these is still open to doubt.

Next in importance are the representatives of the CAPE FLORA, (no less sharply defined than the Australian), which is undoubtedly represented by *Widdringtonia*, the genera *Protea* and *Leucadendron*, *Euclea*, *Royena*, *Cunonia*, and the *Celastrineæ*, the latter being especially represented by numerous forms, closely resembling those now living. A list of twenty-three other genera is given, and the representation in European Tertiary Floras is so complete that but six distinctive families of the Cape Flora are not found, and these are of plants whose growth is for the most part unfavourable to their preservation as fossils.

The CENTRAL AFRICAN TROPICAL REGION (Sudangebiet) is represented by the well-marked genera *Gardenia* and *Boscia*, and by analogues of specific forms peculiar to this region.

TROPICAL ASIA (Monsungebiet) is represented by a great assemblage of species and genera. which are noteworthy on account of their wide distribution in the Tertiary strata; these are *Engelhardtia*, *Dalbergia*, *Cæsalpina*, *Pterospermum*. [Twelve other characteristic genera are named, and 37 analogues of East Indian types.]

Less in number, but of more striking form, and also widely distributed in the Tertiaries, are the representatives of the CHINO-JAPANESE region. Four characteristic species of Coniferæ, *Thuiopsis* of Japan, *Glyptostrobus* and *Cunninghamia* of China, and *Salisburia* common to China and Japan; *Cinnamomum* and *Koelreuteria*; besides a host of analogous species of *Pinus*, *Podocarpus*, *Betula*, *Ulmus*, and ten other not less important genera, represent this region in the Tertiary Flora.

STEPPE-REGION (Steppengebiet). The representatives of this region are by comparison only subordinate; but three genera, now exclusively confined to it, are present, *Planera*, *Parrotia*, and *Pterocarya*; but species are met with, analogous with those characterizing the region, of eleven more widely distributed genera.

Representatives of the MEDITERRANEAN and the temperate regions of the Eastern and Western Continents are the most numerous of all in the European Tertiary Floras. It is remarkable that the more the Australian elements are present, the less in number these are, and *vice versâ* the more these preponderate, the less the Australian elements seem to dominate. Thus in the Floras of Sotzka, Häring, and Monte Promina, the proportion of Australian forms is 1 in 3; in the Flora of Sagor and Kutschlin 1 in 6; of Radaboj and Leoben 1 in 14; of Bilin 1 in 16; of Œningen 1 in 30; and in the Pliocene Flora but 1 in 40. On the other hand, we find 1 representative of the Mediterranean or Temperate regions in 11 or 12 in the Floras of Sotzka, Häring, and Monte Promina; 1 in 7 at Sagor; 1 in 6 at

Kutschlin; 1 in 4 at Radaboj, Leoben, and Bilin; one-third at Œningen, and half in the Pliocene. [The list of fossil genera agreeing with those of the Mediterranean region contains 41 names.]

Analogues of the floras of the Temperate regions have been met with in every locality, from which Tertiary fossil plants have been obtained. They are divided into those which are common to both, and those which are peculiar to one of these, the European or American Temperate regions. Included in the former are the ferns *Aspidium* and *Osmunda,* and a number of genera of familiar trees and plants, as pine, oak, beech, elm, poplar, holly, lime, etc., the Tertiary forms of which correspond with species now living both in Europe and America. A number of fossils on the other hand, belonging to genera now common to both hemispheres, resemble species peculiar to one or other only. For instance, the species of *Myrica* are all of North American aspect, the European forms not being represented, whilst only European forms of *Castanea* have been met with.

[Thirty-five genera are mentioned, a large proportion of which are monocotyledons (4 aquatic), whose analogues existed in either one or other Continent, or which cannot be referred with certainty to either. The list includes 2 Gymnosperms, *Juniperus* and *Taxus.* The most remarkable of the dicotyledons are *Castanea, Alnus* and *Salix.*]

As representatives of the Flora of the Temperate region of the Western Continent, there are 37 genera, besides those common to Europe, amongst which are *Smilax, Sabal, Platanus, Magnolia, Sapindus, Carya, Rhus, Juglans, Spiræa, Cassia,* etc.

The Flora of the PRAIRIE region is represented by some analogues of species of *Quercus, Populus,* and four other genera; the CALIFORNIAN COAST REGION by the genus *Sequoia* and species of *Pinus, Quercus, Myrica. Fraxinus, Juglans, Salix,* etc.; the MEXICAN REGION by species of *Quercus, Ficus, Symplocos,* and 5 others; the WEST INDIES by species of *Sabal, Dodonæa, Celastrus, Myrtus, Cassia,* and 9 others.

More fully represented than any of these is the vegetation of tropical South America, no less than 59 genera being found; of these *Andromeda, Aralia, Cæsalpinia, Mimosa, Acacia,* and *Sapindus* are familiar genera.

The CHILIAN TERRITORY is represented by few, but distinctive genera [11, including *Podocarpus, Celastrus,* and *Arbutus.*]

The OCEANIC ISLAND FLORAS are represented as follows:—Azores, Madeira and Canaries by 4 ferns, *Aspidium, Cheilanthes, Pteris, Woodwardia,* and by *Laurus, Dracæna,* and 6 other genera; Madagascar by *Andromeda* and *Elæodendron*; Mascarenes by *Erythroxylon, Celastrus* and *Elæodendron*; Sandwich Isles by *Metrosideros*; Norfolk Isle by *Pisonia, Elæodendron, Baloghia*; New Zealand by *Hedycarya, Panax, Weinmannia* and *Edwardsia.*

NOTICES OF MEMOIRS.

I.—NOTE SUR LE TERRAIN DEVONIEN DE LA RADE DE BREST. By Dr. CH. BARROIS. (Ann. de la Soc. Géol. du Nord, vol. iv. p. 59.)

THE Devonian strata of Britanny are found scattered here and there in the synclinal hollows of the Silurian beds, and have formed the subject of numerous papers by many eminent French geologists. They consists of sandstones, grauwacke, limestones, and schists and are divided by the author into five sections, each characterized by its distinct assemblage of fossils. M. Barrois carefully describes these several divisions and their contained fauna; and discusses their probable equivalents in other regions. His views on this latter point will be best gathered from the following table, which he has provisionally drawn up.

DIVISIONS OF THE LOWER DEVONIAN.

RADE DE BREST.	NASSAU.	ARDENNES, EIFEL.
III. Schists of Porsguen. } Schists of Fret. Schists of Porsguen.	Schists of Wissenbach.	Iron Ore of Fourmies, with *Spirifer cultrijugatus.*
		Grauwacke of Hierges (base). Red Schists of Vireux and Burnot. Black Sandstone of Vireux.
II. Grauwacke of Fauo. } **Foliated schists, slates. Limestone. Grauwacke.**	**Grauwacke of Coblentz** } **Slates. Limestone. Grauwacke.**	**Hundsrückian.** } **Slates of Alle. Limestone of Bouillon. Grauwacke of Montigny.**
I. White Sandstone of Landevennec. } **White Sandstone. Iron Ore.**	**Taunus Sandstone. Johannisberg Ore.**	**Anor Sandstone.**
		Gedinian.

II.—THE GEOLOGY OF THE NORTHERN PART OF THE ENGLISH LAKE DISTRICT. [Description of Quarter-sheet 101 S.E. of the Geological Survey Map of England and Wales.] By J. CLIFTON WARD, F.G.S., etc. 8vo. pp. 132. (London. 1876.)

THIS Memoir, the first issued by the Geological Survey in description of the Lake District, is devoted to an account of the geology of the country around Keswick, including the lakes of Ullswater, Thurlmere, Derwentwater, Bassenthwaite, Crummock Water, Buttermere and Ennerdale. Mr. Ward commences with a brief account of the Physical Geography, and then gives a general description of the rocks; these embrace the Skiddaw Slate, the Volcanic Series of Borrowdale (Green Slates and Porphyries), the Basement Conglomerate (often called Upper Old Red Sandstone), the Carboniferous Limestone, Glacial Deposits and Alluvium. Besides these are numerous Igneous Rocks. All are described in detail, as well as the character and causes of metamorphism. Much attention has been given to the Igneous Rocks (a new feature in connexion with the Survey publications); and the work is accompanied by three coloured plates of microscopic sections of these rocks.

The faults and mineral veins are described, and one chapter is devoted to Plumbago or Graphite. Cleavage is the subject of another brief chapter, while the Physical History of each formation is dwelt upon at more length. The Glacial Phenomena of the District, and the Relation of the Scenery to Geology receive due attention, and the concluding chapter is devoted to the fossils of the Skiddaw Slate. In an Appendix Mr. Etheridge describes some new species of Trilobites from this formation, and one new genus of Annelida, termed *Stella-scolites.* There is also a useful Appendix containing a list of all works bearing on the geology of the district.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—April 25th, 1877.—Prof. P. Martin Duncan, M.B., F.R.S., President. in the Chair.

1. "On the Upper Limit of the essentially Marine Beds of the Carboniferous System, and the necessity for the establishment of a 'Middle Carboniferous Group.'" By Prof. E. Hull, F.R.S., F.G.S.

The author, in this paper, divided the whole of the Carboniferous rocks into successive stages from A to G inclusive, taking the Carboniferous beds of Lancashire as a type, and showed that these stages could be identified over the whole of the British Isles. It was only recently that their determination had been made in Ireland, so that until now the materials had not existed for a complete correlation of the series in the British Islands. The following is an abbreviated statement of the representative stages in descending order:—

Essentially Freshwater or Estuarine, with one or two Marine Bands.

Stage G.—*Upper Coal-measures* of Lancashire (2000 ft.) and other English coal-fields. Red Sandstones, etc., of Bothwell and Ayr. in Scotland. (Absent in Ireland.)

Stage F.—*Middle Coal-measures* of Lancashire, etc., with principal coal-seams (3000 ft.). Flat coal series of Scotland. Present in Ireland (Tyrone, Kilkenny).

Essentially Marine.

Stage E.—"*Gannister Beds*" (Phillips), with marine shells and thin coals (2000 ft.), in Lancashire. "Pennystone series" of Coalbrook Dale, South Wales, etc. "Slaty black-band" series of Scotland. (Present in Ireland, Kilkenny, Dungannon, Lough Allen Coal-fields.) Also in Belgium, Rhenish Provinces, and Silesia, with numerous marine shells.

Stage D.—*Millstone Grit Series* of England and Wales. 3500 ft. in Lancashire; "Moorstone Rock" of Scotland; "Flagstone-series" of Carlow and Kilkenny; Millstone Grit of Fermanagh and Leitrim, with coals and marine shells.

Stage C.—***Yoredale Beds.*** **3000 feet in Lancashire; Upper Limestones and "Lower Coal and Ironstone series" of Scotland; Shale series of Kilkenny and Carlow; Ironstone shales of Lough Allen, with marine shells.**

Stage B. — ***Carboniferous Limestone.*** **Mountain Limestone of Derbyshire; "Scaur Limestone" in Yorkshire; "Lower Limestone" (Roman camp) of Scotland; Carboniferous Limestone of Ireland.**

Stage A.—***Lower Limestone Shale*** of England. **Calciferous Sandstone series ("Tuedian," Tate) of N. of England and Scotland; Lower Carboniferous Sandstone, N. of Ireland; Lower Carboniferous slate, with Coomhola grits, with marine shells, S. of Ireland. (In Scotland, estuarine or lacustrine.)**

Palæontological Results.—**On making a census of the Mollusca and other fossils from the various stages above that of the Carboniferous Limestone (Stage B.) as determined by the palæontologist** of **the Geological Survey, some interesting results were obtained, showing the prevalence of marine conditions up into Stage E, and a general change in the character of the fauna in the succeeding stages. Including only the area of the British Islands, it was found that no fewer than 37 genera, with 74 or 75 species, of decidedly marine forms, occur in the Gannister-beds (Stage E), of which all the genera and about 40 species were known in the stage of the Carboniferous Limestone.[1] The series includes *Phillipsia*, which has been found by Dr. F. Römer, in the representatives of Stage E in Silesia.**

On the other hand, of the whole number of species in Stage E (Gannister beds), only 6 are known in the overlying Stages F and G, these being characterized by the prevalence of bivalves of supposed lacustrine or estuarine habitats, variously called "*Unio*" and "*Anthracosia.*" Of the few species of marine genera known in Stage F (Middle Coal-measures), about 5 or 6 species are peculiar to itself, according to the determination of the late Mr. Salter.

Such a remarkable difference in the fauna of the Upper and Middle Coal-measures, as compared with that of the Gannister beds, constituted, in the author's opinion, sufficient grounds for drawing a divisional line between those two divisions of the Carboniferous series. Of the several existing methods of classification adopted by different authors, none of them appeared sufficiently to recognize the palæontological distinctions and characteristics of the several formations. The large number of genera and species which are now known to range up from the Carboniferous Limestone into the Gannister beds, and no higher, indicated the proper horizon for a divisional line, in fact a palæontological break at the top of the Gannister beds.

On the other hand, the mineral and palæontological differences between the Carboniferous Limestone and the overlying Yoredale series[1] were sufficient to justify their separation into distinct divisions; while the Yoredale, Millstone Grit, and Gannister series, are related by close mineral and palæontological resemblances.

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[1] In the discussion which followed the reading of Prof. Hull's paper, the author in replying remarked that it seemed to him that sufficient importance had not been given to the palæontological break above the Gannister beds; out of 74 species of marine genera below this line not more than 6 pass upwards.

With a view, therefore, of bringing the classification of the Carboniferous series into harmony with the character of the representative faunas, and the physical features of the successive stages, the author suggests that Stages C, D, and E, composed of essentially marine beds, should be united into a Middle Carboniferous group; while Stages F and G would remain as at present, in the Upper Carboniferous, their fauna being essentially of fresh water. The series, as thus amended, would be as follows:—

Upper Carboniferous Group.

Stage G.	Upper Coal-measures	Essentially freshwater.
„ F.	Middle Coal-measures	

Middle Carboniferous Group.

Stage E.	Lower Coal-measures or Gannister Beds	Essentially Marine.
„ D.	Millstone-Grit series	
„ C.	Yoredale series	

Lower Carboniferous Group.

Stage B.	Carboniferous Limestone series	Essentially marine (except in Scotland).
„ A.	Lower shales, slates, carboniferous and calciferous and sandstone series	

The author then proceeded to show, by reference to the writings of Dr. F. Römer of Breslau, of M. De Koninck, M. Charles Barrois, etc., that Stage E with its marine fauna is represented both in Germany, Belgium, and France, as well as in the British Islands, so that the classification would hold good over Western Europe, which was a sufficiently extensive area to justify the establishment of a distinct group of strata.

2. "On Coal-pebbles and their Derivation." By H. K. Jordan, Esq., F.G.S.

In this paper the author endeavoured to explain the mode of production of pebbles of coal in the clays and sandstones of the South Wales Coal-field and elsewhere, the occurrence of which had been long since noticed by Sir William Logan and Sir Henry de la Beche. His opinion is that the pebbles in question are derived either from the seam of coal above which they are found, or from a seam of coal which formerly existed in the same, or approximately in the same position, and which has been destroyed by erosion, the effect of strong currents of water, which distributed the grains of sand and other materials upon the coal-seam.

II.—May 9th, 1877.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.

1. "On the Agassizian Genera *Amblypterus*, *Palæoniscus*, *Gyrolepis*, and *Pygopterus*." By Ramsay H. Traquair, Esq., M.D., F.R.S.E., F.G.S.

The author's object in this paper was to discuss the characters by which the above genera of fossil fishes have been supposed to be distinguished in the case of specimens from the Carboniferous series. In *Amblypterus* he distinguished five types among the species referred to that genus by Agassiz, viz.:—I. Of *A. latus;* II. *A. macropterus* = genus *Rhabdolepis*, Trosch.; III. Of *A. striatus* = *Cosmoptychius*, g. n.; IV. Of *A. nemopterus* = genus *Elonichthys*, Gieb.; V. Of *A. punctatus* = *Gonatodus*, g. n. In *Palæoniscus* he distinguished the following types:—I. Of *P. Freieslebeni;* II. Of *P. Duvernoyi* = genus *Amblypterus*, Ag.; III. Of *P. striolatus* = genus *Elonichthys*, Gieb.; of *P. ornatissimus* = *Rhadinichthys*, g.n.; VI. Of *glaphyrus* = *Acentrophorus*, g. n.; VII. Of *P. catopterus* = genus *Dictyopyge*, Egert. He further discussed at great length the characters and affinities of the genera *Gyrolepis* and *Pygopterus*, the former of which he regarded as untenable, on the ground of its being founded on fragmentary remains of fishes belonging to several other genera; and the latter as divisible into the following groups:—I. Type of *P. Humboldtii*, Permian only; II. Type of *P. Bucklandi*=*Elonichthys*, Gieb.; III. Type of *P. Greenockii*=*Nematoptychius*, g. n. There are no Carboniferous species of *Pygopterus* proper.

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[1] In the south of Ireland there is strong evidence that the Yoredale beds ("Shale-series") are unconformable to the Carboniferous Limestone.

2. "On the Circinate Vernation, Fructification, and Varieties of *Sphenopteris affinis*, and on *Staphylopteris? Peachii*, Etheridge and Balfour, a Genus of Plants new to British Rocks." By C. W. Peach, Esq., A.L.S. Communicated by Robert Etheridge, Esq., F.R.S., V.P.G.S.

The author noticed the occurrence in the Carboniferous shales near West Calder (Edinburgh) of abundant remains of the fern described by Lindley and Hutton as *Sphenopteris affinis*, dwelling especially on the circinate vernation and supposed fructification of the plant. With it were found many fragments of small flower-like plants, which had been referred to the genus *Staphylopteris*, Presl, the fructification especially resembling that ascribed to that genus. The author considered that in all probability the *Staphylopteris* was parasitic upon the *Sphenopteris*, perhaps after the fashion of *Cuscuta* upon flowering plants.

Discussion.—Mr. Carruthers spoke in high terms of appreciation of Mr. Peach's work in nearly all departments of Natural History. The greatest credit was due to him for his exceedingly careful observations. At the same time Mr. Carruthers was compelled to differ from him with regard to the plants which had been brought before the Society on this occasion. The structure of the fruit in some of Stur's coal-plants is the same as in the living *Hymenophyllum*, consisting of two valves peculiarly arranged, the lower pinnæ of the fronds being fertile and modified accordingly. The same thing seems to have occurred in *Sphenopteris affinis*, except that the lower pinnæ retained their normal structure, and the apical pinnæ were modified as the fruit-bearing portion, which had been regarded as forming the peculiar genus *Staphylopteris*.

3. "On the Occurrence of a Macrurous Decapod (*Anthrapalæmon Woodwardi*, sp. nov.) in the Red Sandstone, or Lowest Group of the Carboniferous Formation in the South-East of Scotland." By Robert Etheridge, Esq., Jun., F.G.S.

After giving a detailed bibliography of the Palæozoic Malacostracous Crustacea, the author described the remains of a small Crustacean from the lower group of the Carboniferous formation near

Dunbar, and discussed its affinities and systematic position, which he regarded as being among the Macrurous Decapods, although the absence of the eyes in the preserved specimens, and some other characters, rendered it doubtful whether it might not in some respects approach the Stomapoda. Its position among the Macrura seemed, however, to be established by the well-developed abdominal somites and telson. He referred the fossil to Salter's genus *Anthrapalæmon*, and named the species *A. Woodwardi*.

4. "On the Stratigraphical Position of the Corals of the Lias of the Midland and Western Counties of England and of South Wales." By R. F. Tomes, Esq. Communicated by R. Etheridge, Esq., F.R.S., V.P.G.S.

The object of this paper was to give the precise stratigraphical position of the species of Liassic Corals collected by the author and his friends in the districts above mentioned. He noticed 41 species, of which 15 were described as new, namely:—*Cyclolites Anningi, Thecosmilia longiserialis, Montlivaltia cyclolites, Thamnastræa Etheridgii, Thecocyathus mucronata, Montlivaltia papyracea*, and several others to which no specific names are attached, chiefly belonging to the genus *Isastræa*.

CORRESPONDENCE.

THE ACTIVE VOLCANO OF OSHIMA.[1]

SIR,—It may interest some of your readers to learn that since my return to Tokei, Japan, I find, from a microscopic examination, the lava from the Island of Oshima appears to be an Augitic Andesite, containing some Sanadine, and on the whole resembling some of the Java rocks, which will make it very interesting. JOHN MILNE.

IMPERIAL COLLEGE OF ENGINEERING, KOGAKURIO, TOKEI, JAPAN.
March 24th, 1877.

EXPLORATION OF VICTORIA CAVE, SETTLE, YORKSHIRE.

SIR,—It was with great surprise that I read, in an abstract of the proceedings of the Geological Society of London, the following passage: "The President asked Prof. Boyd Dawkins whether the impression which prevailed in some quarters that there had been a want of care in the excavation of the Victoria Cave was well founded."

Having lived for a long time in the north of England, and having paid several visits to the Cave, since Mr. Tiddeman has had the charge of it, I feel bound to state that I have always been struck with the great care shown in the excavation, and with the scrupulous accuracy with which the position of every article found was noted.

I am morally certain that there is no ground whatever for any imputation of carelessness; it would indeed be a gross injustice both to Mr. Tiddeman, who has so generously sacrificed so much of his spare time to the work, and also to Mr. Jackson, the discoverer of the Cave. J. R. DAKYNS.

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[1] See "Account of a Visit to the Active Volcano of Oshima" in GEOL. MAG. May, 1877, p. 193.

GOLD IN THE COAL-MEASURES OF NEW SOUTH WALES.

SIR,—The following important facts, abstracted from a report by my friend Mr. C. S. Wilkinson, F.G.S., Government Geologist of New South Wales, to the Minister of Mines of that Colony, on the occurrence of payable gold in the New South Wales Coal-measures, may be of interest to your readers. Mr. Wilkinson observed that the gold found in the alluvial deposits of Tertiary age at the Old Tallawang and Clough's Gully diggings was derived from conglomerates of Coal-measure age, associated with sandstone and shale containing the very characteristic genus of fossil plants, *Glossopteris*. At Clough's Gully the conglomerate *in situ* is worked for gold, and has yielded nuggets weighing as much as five ounces. This is the first time that payable gold has been noticed to occur in the New South Wales Coal-measures, although it is to that veteran in Australian geology, the Rev. W. B. Clarke, F.R.S., and the late Sir T. L. Mitchell, Surveyor General of New South Wales, that we are indebted for the first announcement of the fact that gold was to be found in rocks of the age in question.[1] Mr. Wilkinson also states that a collection of fossil fruits obtained from the "Black Lead," Gulgong, under a stratum of Basalt, and at a depth of 163 feet from the surface, has yielded to the researches of the Baron F. von Müller, M.D., F.R.S., etc., seven genera and nine species of new forms. The report concludes with a reference to another important, and at present, unique discovery by Mr. Wilkinson, that of a species of *Unio* in one of the Gulgong "deep leads," "the first fossil shell of the kind yet discovered in the Pliocene Tertiary gold drifts."[2]

EDINBURGH, *March* 28, 1877. R. ETHERIDGE, Jun.

NATURAL OR ARTIFICIAL? PITS OF THE HAUTE MARNE.

SIR,—At p. 210 of Le Bassin de Paris, by M. E. Belgrand, a letter from M. Royer is inserted giving the following account of some singular excavations in the Portland Plateaux, Haute Marne.

"On the high hills of the town of Poissons near Joinville, the culminating point of which reaches the height of 200 mètres above the river Rongeant, these cavities, from their depth and extent, acquire unusual importance; certain of these hills are literally riddled with pits (puits) ramifying in all directions, sometimes having a subterranean communication one with another and reaching unascertained depths, sometimes exceeding 30 or 40 mètres. The general character of these pits and the polish of their rocky walls suggest that an acid contained in the waters by which they were eroded, may have contributed to their excavation; but their extent and number suggest some more powerful agent; and what more powerful cause could you invoke than a great quantity of water, acting through a long period, falling into the fissures of the Portland rock, enlarging them, fashioning them, and giving them the capricious forms which we find everywhere in rocks subjected to their action? . . . . Now among the debris which have filled these cavities . . . bones of the great mammalia of the Quaternary period have been found." (Elephant.)

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[1] Clarke's Southern Goldfields, New South Wales, 1860, pp. 44 and 244.

[2] *Sydney Evening News*, No. 2940, November 30th; and *Sydney Morning Herald*, December 2nd, 1876.

There is a difference of opinion as to the date of the excavation: M. Royer contending that it was before, and M. Belgrand that it was after, the excavation of the valleys; but both agree in attributing these pits to the action of a vast quantity of water, whether produced by a diluvial cataclysm, or else by the incessant rains of the Pluvial period in which they both believe. The description immediately suggested to me a strong resemblance to "Grimes Graves," near Brandon, an account of which will be found in the Journal of the Ethnological Society of London, New Series, vol. ii. p. 419, in an article on the opening of Grimes Graves, in Norfolk, by the Rev. William Greenwell, M.A., F.S.A.

Beyond all question Grimes Graves were excavated by the manufacturers of flint implements; and they were sunk to a depth of 30 or 40 feet in order to reach a layer of flint especially suited to their purpose. There are some circumstances mentioned by M. Royer in which his pits agree with these: their great number, the subterranean communication one with another, and lastly the form, so far as it is suggested by the French words '*puit*' and '*gouffre*,' both applied to these pits. M. Royer speaks of "capricious forms," which seems to betray the fact, that he is puzzled to know how those vast waters could have done it so regularly (?). The depth of "some of them," 30 to 40 mètres, is indeed somewhat staggering, being three times the depth of the Brandon pits, and the rock is not Chalk, but corresponds in age to our Portland. M. Contejean, in his "Éléments de Geologie et de Paléontologie," p. 620, describes the "terrain jurassique" as consisting in thick argillaceous and calcareous beds (massifs), often irregularly alternating, and as including, at various levels, ferruginous layers, and layers of *flint nodules*. And at p. 426 he says, siliceous nodules (rognons) exist in all sedimentary deposits, but especially in the Jura limestone and in chalk. What is the precise nature of the Upper Oolite in Burgundy and Champagne my library does not give me the means of knowing. Burat only remarks that it does not present such marked forms (due to the outcrop of limestone) as the middle and lower Oolite; the argillaceous part (assise) at the base is but little developed; the greyish or yellowish-grey calcareous beds (calcaires) of the upper part (assise), which are found at first in isolated outliers, on the summits of the middle stage (étage moyen), end by forming, at the foot of those summits, an undulating surface of hills with more or less gentle slopes, with altitudes of not more than 150 and 200 mètres, the inclines and escarpments of which are less conspicuous. Among localities where the beds may be studied, he mentions Bar-le-duc, Bar-sur-Seine, and Auxerre; and says that in the Portland beds the limestone is too much divided to be quarried, and forms stony plateaux (p. 440). It does not appear from these authorities that any insuperable impediment exists to such pits having been sunk by man; and the suggestion is countenanced by

the fact, that although in the comparatively narrow and steep valleys traversing this formation, there is but little gravel, and no implements have been found, yet on the uplands numerous and well-made flint implements have been collected, from what M. Belgrand calls the *hunting stations*.

It may seem strange that if these pits really do present the similarity to Grimes Graves which I have supposed, the idea should not have occurred to the French geologists; they may never have heard of our pits; but I find it stated that in the Memoires de la Société des Sciences, etc., du Hainaut, Année 1866–7, published at Mons, 1868, there is a paper, relating to similar ancient works, by MM. Briart, Cornet and De la Haie (Rapport sur les Découvertes géologiques, etc., faites à Spiennes en 1867), and that those works were known as long ago as 1842. I have not seen this article, and can find no account of it in my books.

If attention has not previously been called to the primâ facie possibility that these pits in Champagne are the work of manufacturers of flint implements, perhaps you will consider the matter of sufficient importance to give it a place in your MAGAZINE. The description is too loose and general to be a ground for anything more than suggestion and inquiry. HENRY NORTON.

21, UNTHANKS ROAD, NORWICH, *April 20th*, 1877.

A NEW SUBMARINE VOLCANO? IN THE MEDITERRANEAN.—An exciting story is going the round of the London journals, calling attention to "a singular accident which lately befell the steamship Knight Templar, 1,550 tons gross register, from Cardiff to Bombay with coal. When off the island of Galita, near the Gulf of Tunis, and, according to the Admiralty Chart, being in a thousand fathoms of water, she suddenly received a violent shock, and was immediately surrounded by a seething mass of foam. Being run ashore, and ultimately examined, it was found that at a distance of 15 feet from the stem of the vessel some 10 feet of her keel had been torn out in a peculiar manner, while the after part of the ship's bottom had also been seriously injured. Altogether the character of the damage done to the ship leads the writer, a Board of Trade surveyor, to the conclusion that the ship's hull had been struck by a submarine volcanic eruption, a theory much strengthened by the well-known character of the locality."

Scrope long since pointed out that the volcanic line of disturbance extends from Calabria and Sicily in a south-westerly direction towards the African coast, and embraces the volcanic island of Pantellaria, and the sunken volcanic island of Ferdinanda, to Cape Bon, the eastern promontory of the Bay of Tunis, linking Sicily with Africa; and that the intervening tract *is known to be very shallow* ("Volcanos," p. 345).

Is it not possible that a *sunken rock* was the cause of the "*Good* Templar's" *scrape*? Anyhow he had a narrow escape, whether struck by a *volcanic bomb under water*, or scraped on a part of the old ridge dividing the Eastern and Western basins of the Mediterranean. We hope the Admiralty will investigate this matter thoroughly.

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No. VII.—JULY, 1877.

ORIGINAL ARTICLES.

I.—Across Europe and Asia.—Travelling Notes.

By Professor John Milne, F.G.S.;
Imperial College of Engineering, Tokei, Japan.

Part I.—London to St. Petersburg.

Contents.—Wearing away and accumulation of land on the coasts of England and Denmark.—Ice-worn character of the coasts of Sweden and Finland probably due to the action of coast ice on a rising area.

I LEFT London on the 3rd of August, 1875, and next morning was sailing down the muddy estuarine waters of the Humber towards the German Ocean *en route* for Gottenborg. On either side was a long line of flat coast. Before us was Spurn Point, which, by the action of the sea, is being fast carried away. The denudation of the eastern coast of England, and the steady encroachment of the sea, which has swallowed up towns and forced others to move inland, is a subject with which all geologists are familiar. Here, where the materials are soft, the rate of waste is rapid enough to become a marked event in the lifetime of an inhabitant. The little town of the Banks has disappeared, and a lighthouse at the entrance to the river has been forced to migrate towards the land.

Although the tides and currents of the sea are destroying and transporting the materials of many coasts to form beds of silt and other matter upon the ocean bottom, there are cases where their action upon a coast is reproductive,—an example of which is to be seen at the northern extremity of Denmark, called the Skagen or Skaw promontory. We sighted this after leaving Spurn. At a distance this point looked like a low white shore. About two miles and a half from the end I could see a buoy, marking the end of a shoal. This shoal the captain told me, when first he knew it, between twenty and thirty years ago, instead of being two miles and a half long, was then only one mile long. The point itself, which I believe is made up of shingle, sand, and other drifted material, also appears to be lengthening, as is indicated by an old lighthouse standing almost a mile back from the new one which has supplanted it at the end of the point. The materials for such rapid growth as is here exhibited appear to have come down the Baltic, the islands lying in a line with the end of the point having been the chief source of supply. Although Denmark is increasing at the Skagen, the losses which it and the neighbouring islands suffer from the flood of water ever pouring between the German Ocean and the Baltic are by no means compensated for. The waste of Denmark is with geologists as fruitful a theme and text as that of Eastern England.

The same evening on which I saw the Skagen I reached Gottenborg. This place is interesting as giving evidence of a slow elevation of the land above the sea-level, without the intervention of any violent agency. Early next morning I had a short ramble across the gneissic hills, which overlook the town. These are smooth and rounded, and have that hummocky character usually attributed to glacial action. Between these, filling up the valleys, were long, flat grassy meads banded with shining strips of water. I did not notice any boulders or drift.

In a small museum in the town I saw a collection of geological specimens, and also a fine series of Scandinavian and other animals. Amongst these latter there was a Swedish Elk which, to me, had a much thinner, taller, and altogether gaunter appearance than the American Moose, with which, by some, it is thought to be identical.

Whilst walking about the town I was much struck with the sections of fossils in the flags which pave the sidewalks. They were nearly all of the genus *Orthoceras*, many being large and beautifully defined. In places these cylindrical bodies were so thickly packed that the sea-bottom on which they were deposited must have been like a floor strewn with spikes. These flagstones come from some of the Silurian islands of the Baltic.

On the evening of the 8th I left Gottenborg for Stockholm. As the train went slowly, so long as daylight lasted I had excellent opportunities of seeing the country through which we passed. For the first part of the journey we traversed a fertile valley bounded on either side by high hills, which in many places showed bare rock. In some places the line was so overhung by trees that they almost swept the tops of the carriages as we passed beneath them, and one might almost fancy oneself in an English lane. Farther up the valley the alluvium, and with it the vegetation, crept some distance from the central trench up the flanking hills. This continued until we reached Lerum, where the cold-looking rocky summits were all decked with the earthy covering, which at a lower level had only stretched across the valley bed. Next morning, just before we reached Stockholm, I saw several cuttings made in the sides of small hills, showing earthy sections about forty feet in height filled with stones and large boulders.

The general opinion with regard to the origin of the rounded rocks like those of Gottenborg, and the beds of clay and boulders as seen near Stockholm, is, that they have been produced through the agency of some form of ice. Glaciers being conspicuous and accessible objects for investigation by the writers on these subjects, have received considerable attention. But there is another probable and possible agent by which appearances of this sort may have been rought about, which by those who talk and write about Ice and its ctions is very often either ignored or forgotten, and this is the ction of Floe or Coast Ice. As I saw some striking examples of he work done by this agent in the next section of my journey along he coast of Finland towards St. Petersburg, I will not digress, but ontinue my itinerary. As the oscillatory movement of the land is ntimately connected with the idea I wish to broach, I may here nention that near Stockholm we appear to have an axis about which he Baltic coast is moving. To the north it is rising, whilst for ome distance to the south it is sinking.

After leaving Stockholm (Aug. 11th) and its flagstones, which, ike those of Gottenborg, are filled with sections of *Orthoceras*, I t once found myself amongst the archipelago of islands which stud he southern and south-western shores of Finland. As the sea was mooth and the weather fine, I had ample opportunity of seeing everyhing around me. Islands were everywhere. In fact they were often o close together that they masked our route; looking backwards we seemed to have sailed away from the land, whilst looking forwards it seemed as if we were steering into it. Sometimes we passed so close to them that we might easily have pitched stones upon them. Where the water was more open, our course was shown by a white mark or a pile of stone upon the land, or by an upright pole standing on some sunken rock.

There is everywhere evidence of reefs and shallow water. The islands vary very much in size, some have an area of several miles, whilst others consist of a mere rock just peeping from the surface of the water. They are generally destitute of vegetation, but some are found capped with small clumps of dark-coloured stunted firs, whilst near the water they are bordered with a fringe of green, looking like bunches of alder. Now every year, as the winter months come round, the water freezes, and every rock and island and the adjoining mainland give birth to a fringe of ice. But this congealation does not go on quietly, it is continually interrupted. By the rise and fall of the tides it is raised and lowered on the shore, strong currents carry portions of it away, the wind and the driving in of floating ice and other causes all tend to destroy any steady formation of a sheet of ice like that which forms on small freshwater lakes and ponds. In this way the first fringe of ice most likely attached to pebbles, boulders, and materials, to which, whilst resting on the shore, it has become cemented, are driven high and dry upon the land, scraping, scratching, and moulding in a definite manner all the rocks over which they pass. Or again, this fringe with its load of stones may by winds and tides be forcibly torn from its birthplace, and borne away to do its work of moulding and depositing of boulders at some distant locality.

Grinding and moulding actions of this sort, together with the transportation and deposition of boulders, will take place chiefly during the formation and breaking up of this icy barrier, which will be in the fall and spring of every year. And the action is by no means confined to Finland, but is one which annually occurs over areas of enormous extent, both in the temperate and frigid zones.[1] Now what must be the effect of such actions upon a coast where we have a gradual elevation of the land in operation, or, to speak more generally, where there is a varying relation between a country and the water which surrounds it? The case I shall take for consideration is where the land may be supposed to be emerging, as in the case of Finland. How this emergence has been produced, whether by an elevation of the land, or by a drawing off of the waters, by an accumulation of polar ice, makes no difference. First, consider the land when it is just beneath the surface of the water, where, in summer time, it forms a heaving curling swell, and often a crest-capped breaker, to warn the passing boats of its dangerous shallows. At this period it comes for the first time within the influence of coast ice, and moulding is begun upon its surface. During winter and spring months passing pans and small bergs of ice jostle on its shallows. Should it possess asperities, they are rounded off. And as it rises higher in the water, it will gradually assume the hump-backed form which is so observable in many of the small rocky islands on the Finnish coast. It will now be within the full influence of all the grinding agents which, during the winter months, float round and attach themselves to its shores. A fringe of ice, set with teeth of stone, is ready at every tide to rise and fall upon its sides, at every wind to be driven high and dry or to be carried away, and with every current to move coastwise scouring and scratching along its rocky shore.

Now what I wish to maintain, and what I have put forward before, is that as the island or coast-line continues to rise, the definite

servation, it is distinctly seen that between the white band pro-
iced by the biannual rubbing of the ice and the dark-coloured rock
hich is above it, there is in many cases an undisturbed contour, the
ammillations, curvatures, and hollows of the one now seen to be
oduced by the ice, run uninterruptedly into the mammillations,
ırvatures, and hollows of the darker rocks above. It seems to me
ıat, as year by year the sea recedes, or as the rock creeps upwards,
carries with it the characters which were impressed upon it when
a lower level, and what is now the dark round lichen-coloured
ock, a century ago may have been the clear white banded rock
ınually scratched and scoured by ice.

The entrance to Abo, which was the first place we touched at
pon the Finnish mainland, is up a long winding inlet bounded by
n undulating country of pinkish granite. Upon the right side as
e entered, the land rose in places somewhat suddenly from the
ater, but nowhere to any considerable height. Everywhere, how-
ver, there was the rounded hummocky character. Upon the hills
hich overlooked the scattered houses and buildings which formed
ıe town this was very noticeable. Everywhere there were numbers
f boulders.

On the evening of the next day (Aug. 12th), after steering in and
ut between innumerable rocks and islands, we reached Helsingfors,
granite-built town standing in a much more open country than
ıat around Abo. Some of the limestone causeways contained
rthoceras.

Now comparing these different pieces of mainland which I saw at
bo, Helsingfors, and at other points, one with the other, one could
ot fail to be struck with their great similarity,—rounded granitic
ocks and scattered granitic rocks, some of which are of an immense
ize, were to be seen nearly everywhere. Two travellers who joined
ur ship at Helsingfors, just returned from near Kajana in the far
orth of Finland, gave me the idea of a country filled with winding
ıkes, but not generally differing in character from that which I had
een looking at.

Continuing northwards to the White Sea and Arctic Ocean, and
hen winding round the northern end of the Baltic through Finland
own to the eastern side of the Scandinavian peninsula, a rough
ndulating country covered with lakes, and often strewn with
oulders, is generally met with.

The agent which moulded this country into its present form, and
trewed it so thick with boulders, would, I think, by most geologists,
e identified as ice, and the only argument that would probably
rise would be as to the way in which it acted.

A universal covering of ice forming one huge glacier, like that
which is now supposed to cover the greater part of Northern Green-
and, might perhaps be the first suggestion. To explain this, a
older climate than that which now exists in these latitudes would
e necessary, and this in its turn would require some great astrono-
nical change, as a variation in the obliquity of the Ecliptic, the
xcentricity of the earth's orbit, the temperature of space, or some

great natural revolution in the distribution of land and water, all of which would involve difficulties and controversy in their explanation. How this universal sheet of ice obtained, and afterwards deposited its boulders might next be questioned. Some would call in a sea of icebergs to solve the problem, and might even go so far as to consider them sufficient to explain the whole of the phenomena in question. Following this latter supposition we are again quickly in the midst of difficulties, passing from question to question whilst endeavouring to affirm or refute a suggestion that is little better than proofless.

Icebergs and their parents, the glaciers, have done and are still doing much towards the formation of the physical outlines of our planet; but yet I think their less imposing but more active and more extensive associate, coast ice, ought at least to take an equal place as a scatterer and modeller of rocks.

In Finland, in Labrador, and in Newfoundland, I have seen the work it has commenced on, that which it has partially finished, and that which, I hold, it has completed. There is the sunken rock barely to be seen at low water, just being rounded; there is the rock standing up above high-water, whitened, smoothed and rounded, by the annual coat of ice, which by winds and tides is forced across its back; and, lastly, there is the large island and the mainland all showing a continuous and unbroken contour from their shores annually invaded by the ice, and those parts which are now removed high above its action. Upon the south coast of Finland one is in a workshop where one sees a workman busy with his tools. Part of his work is only commenced, part is almost completed, whilst the remainder is finished and laid aside. Amongst all these specimens of work there is a resemblance, and it is hardly fair to imagine that one part should have been made in a manner different to another.

Let the whole of the Finnish archipelago continue slowly rising above the level of the sea as it now appears to be doing, I think that in time to come there will be produced a low undulating ice-scratched boulder-covered country, very much resembling the one we see upon the adjoining mainland.

One striking instance of the formation of a miniature mainland I noticed shortly after leaving Abo, when we passed a low island about 50 to 100 yards in length. At each extremity of the island there was a round ice-scratched knoll. These two knolls were joined by two narrow ridges, between which there was a hollow, over into which the sea had washed to form a pool. The history of this little formation seemed to me similar to that of many larger areas.

The first stage was when the two knolls had been represented by two sunken rocks, over which the waves might have been seen heaving and swelling as they passed across their surface. Thus far their existence was only recognized by the disturbance they created. However, the nuclei of a little continent was formed, and its surface was annually swept by ice. The next stage was when the knolls appeared as two separate rocks above the surface of the water, the intervening ridge being still hidden; a position analogous to the resent position of the whole Finnish archipelago. As they rose till higher, they entered upon the third stage in which I saw them, epresenting, in miniature, a small country where part of the land as been raised high above the action of ice, whilst the remainder et lies within its influence. In such a case as this we have a small sland formed by the rise of two small rocks. Why can we not then o further and picture to ourselves the formation of many islands hich, as they emerge from their watery bed, unite to form countries arked and moulded like the nuclei from which they spring? It s certainly not a great stretch of the imagination.

All geologists grant that oscillations of land and water have taken lace, and this together with the present or such slightly modified limatal conditions as would result from these changes is all that is sked. If it were conceded that through some such cause as a polar xtension of land in the Eastern Hemisphere, the formation of a cold urrent travelling towards the south, or the cutting off of the Gulf tream travelling towards the north, we might then reasonably exect to have a climate in Europe not unlike that of corresponding atitudes in America, and the effects of coast ice might be expected t least so far south as the middle of France; nay more, if Europe ad been a rising area during such periods, the greater part of its urface would have been gradually subject to such an action.

Commencing with Belgium and Holland, and travelling eastward ver Denmark, North Germany, Poland, and as far east as Novgorod n Russia, then north to the White Sea, and west over Scandinavia, xcepting its high central portions, there is an area which has been ubject to oscillation during late geological times; and if, during these imes, such climatal conditions existed in Europe as now exist in merica, I think we might in many places look successfully for the ction of old coast-ice upon old coast-lines.

Of course many objections may be raised to such a view as this, ut there will be more still to matters of detail in the production f certain observed phenomena by the agent which we suppose to be ere employed, rather than to the weightier objections which are aised as to the ways and means of the production of the agent self invoked by glacialists. We all know into how much ifficulty, uncertainty, and speculation we find ourselves involved hen we endeavour to conceive the manner of production and ethod of action of that immense glacier which by some is upposed to have covered Northern Europe. Granted oscilation of land, and a climate not more intense than that of North merica, and all those astronomical and physical questions as to hat gave birth to the heat and cold necessary for the production of uge continental glaciers, together with much speculation, controersy, and other products of the imagination, are done away with. ppearances similar to those which I have described as having been een along the coast of Finland, I have also seen along nearly 4000 iles of coast in Labrador and Newfoundland. In many places the ocks are striated and often worn and smoothed. This latter effect ore especially has been recorded by Lyell, Campbell, Packard, and other visitors to those shores. The countries which surround such smooth-worn coast-lines, like Finland, give evidences of recent elevation, and moreover both lands show a similar ice-worn surface, over which boulders in varying quantities are everywhere scattered.

Ancient glaciers, many of which were of large extent, together with icebergs, have no doubt done their share as tools in Nature's workshop. But there is another form of ice which, when thought of, comes readily to the front, and that is Coast Ice. How far this agent may have acted in the modelling of continents I have only speculated on; but how far it has been influential in the modelling of islands, coast-lines, and low-lying countries, I have already stated my convictions upon. In conclusion I may state that to my mind it is certain that, on further observation, the action of coast ice will be proved to have been far more extensive than geologists have hitherto supposed.

On the night of the 12th August we left the town of Helsingfors, and all next day were slowly steaming across the quiet waters at the head of the Gulf of Finland. About 4 P.M. we ran between the formidable-looking forts of Cronstadt, and shortly afterwards sighted the huge gilt dome which crowns St. Isaac's cathedral, the glory of St. Petersburg.

If we look at the map appended to chap. xxvi. in Geikie's Great Ice Age, on which are indicated the general directions of ice action in the northern parts of Europe, their directions, which all point *seawards, or else towards the lowest land*, will be seen to be *rather more* favourable for the views which I have advocated than they are for those which they are more particularly intended to support, which are that the ice radiated from "the high grounds of Norway and Sweden, flowing north and north-east into the Arctic Ocean, and east into the White Sea."

It is difficult to conceive, as most geologists do, that the northern drift and its associated boulders are a purely marine deposit, for to have been this it is necessary that at one time they must have passed from beneath the water where they were deposited through a surging coast-line, in order to reach the elevated position they now occupy, during which period they would have been subject to such degradation which none but deposits of extraordinary thickness could well withstand.

A similar objection might be raised respecting the existence of any scratches and roundings produced by land glaciers, if it is ever supposed that they were subsequently beneath the sea. Such markings to be preserved must always have remained above sea-level, or else have been shielded by some protective covering during both subsidence and elevation.

If we read Chapter xxvi. of Geikie's "Great Ice Age," which treats of the glaciation of Norway, Sweden, and Finland, we find much evidence which is unintentionally favourable to my argument. For example, at the end of the chapter, p. 397, the immense power of coast-ice upon the coast of Finland is spoken of, and a case is cited of an immense raft of ice being driven ashore which overwhelmed many dwellings and whole forests. After it had melted, many stones and blocks were found piled in great quantities upon the ground.

The existence of blocks at heights considerably above the positions from which they originated, of which there are many remarkable examples in Sweden, is another phenomenon which points to the action of coast-ice upon a rising area for its explanation.

Huge glaciers and ice-caps, together with subsidences and elevations, explain many local phenomena which the agent I have chosen would by itself be incapable of giving a direct answer to. But it must be remembered that, on the other hand, coast ice acting on a rising area offers explanations to other questions, as in the case of boulders raised to positions above the rock from which they were derived, where glaciers and ice are comparatively incapable of furnishing an answer, so that the relative merits of these two agents are to some extent divided.

The abrading action of coast-ice on a rising area is an undoubted fact, and one that is *now* actively going on before our eyes. Slight physical changes in past geological times may have so intensified it that its effects were to be seen as far south in the Old World as they are now in the New World. Huge glaciers and ice-caps, on the other hand, are phenomena whose existence can only be established by hard fighting.

Admitting the excentricity of the earth's orbit and other cosmical changes, Arago denied that ice-caps would result, Herschel barely admitted their possibility, whilst other astronomers, to whom geologists look as to the last peg upon which they can hang their hopes, are unceasingly occupied in one controversy or another. This being the case, so far as the origin of the agent with which we deal is concerned, coast-ice must come prominently to the fore. Not only upon such a point as this, but also if we were to consider the general devastating influence which would result from anything like a universal covering of ice in our northern regions, we again find ourselves face to face with difficulties, the explanation of which would not be called for, if we are content to extend our ideas respecting the efficacy of coast-ice upon a rising area.

In conclusion, I may say that I feel convinced that Coast Ice has done and is doing much towards the modelling of rising areas, but how far this has extended yet needs investigation. In bye-gone times the climate was colder than it is now, and coast-ice extended farther south than it does at present. During this period many glaciers were increased, and many, especially in the higher regions, were called into existence; but that these ever filled oceans and covered continents, I do not see the necessity of supposing, unless it be to create materials for amazement and debate.

(To be continued in our next Number.)

II.—ON THE AGE OF THE MAMMALIAN ROOTLET-BED AT KESSINGLAND.[1]

By J. H. BLAKE, F.G.S., Assoc. Inst. C.E.;
Of H. M. Geological Survey of England and Wales.

IN two papers, by Messrs. S. V. Wood, jun., and F. W. Harmer, recently read before the Geological Society,—alluded to by Mr. Belt, in the GEOLOGICAL MAGAZINE for April last,—this Rootlet-bed at Kessingland has been referred to, and described as an interglacial shallow valley deposit; of an age posterior to the Contorted Drift or Lower Boulder-clay, lying in a trough excavated out of the Chillesford Clay. To make their description more intelligible, the authors (Messrs. Wood and Harmer) subjoin a sketch-map—in their combined paper "Observations on the Later Tertiary Geology of East Anglia," read November 8th, 1876—and indicate by a broken line the connexion of this trough with the existing (!) valley systems of the rivers Waveney and Yare—which are here mainly cut out of the Chalky Boulder-clay and Middle Glacial Sands—thus apparently assuming that, before the Middle Glacial Sands and Chalky Boulder-clay were deposited, there were valley systems occupying much the same positions in this immediate locality as there are now, with the addition of the supposed continuation of the interglacial valley of the Waveney in a south-easterly direction to Pakefield and Kessingland. To strengthen their argument, they likewise give an *hypothetical* section; representing, what they believe to be the true, *though concealed*, structure of this Waveney valley. They conclude this portion of their paper by stating, "If these views (as propounded by them) are right, there seems reason for suspecting that this Kessingland-bed, containing Mammalian remains and rootlets (which is directly overlain by the Middle Glacial), may belong to the period of interglacial valley excavation we have been discussing"—that is, posterior to the Contorted Drift or Lower Boulder-clay.

I will now refer to Mr. Harmer's paper "On the Kessingland Cliff-section," etc., read November 8th, 1876. After criticizing, generally, Mr. Gunn's paper "On the Presence of the Forest-bed Series at Kessingland and Pakefield," etc., read November 17th, 1875; and expounding his own views as to the sequence of the beds, etc.; Mr. Harmer states, "While, however, the posteriority of these Mammaliferous and fresh-water deposits (Rootlet-bed, etc.) to the Crag (Chillesford Clay) seems thus apparent,[2] their age relatively to the beds newer than the Crag is obscure, since *there is nothing to show whether they preceded the Lower Glacial beds*, which are absent from the Kessingland section, or succeeded them—a point of considerable interest, in reference to the great denudation which, as Mr. Wood and I (Mr. Harmer) maintain, followed the Lower Glacial formation when the valley-system of East Anglia was, we believe, mainly excavated."

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[1] This paper is published by permission of the Director-General of the Geological Survey.

[2] The section of the Kessingland Cliff given (in the Quart. Journ. Geol. Society, vol. xxxiii. p. 137) to show this—besides being inaccurate, together with the description of it, in some important particulars—is very deceptive in appearance, owing to the distorted scale to which it is drawn (the vertical scale being about 13 times that of the horizontal), and also on account of the interval between Covehithe and Kessingland (a distance of about 2¼ miles) being abridged.

It is quite unnecessary—as will presently appear—to follow Messrs. Wood and Harmer, any further in their theoretical views, as to this Rootlet-bed being a deposit formed posteriorly to the Contorted Drift or Lower Boulder-clay, and during the great denudation which they maintain took place previously to the deposition of the Middle Glacial Sands, marking a long interval of time, and which, they state, must have been accompanied by a climate as temperate as that of the preglacial Forest-bed of the North Norfolk coast, if their suggestion of the interglacial age of the Kessingland-bed should prove to have good foundation, etc., etc.; inasmuch, as the Rootlet-bed, containing mammalian remains, can be proved by superposition, irrespective of all other considerations, to *underlie* the Contorted Drift or Lower Boulder-clay and other Lower Glacial beds; therefore, is clearly not of the age suggested by the authors of these papers.

Messrs. Wood and Harmer mention this Rootlet-bed as "the well-known Kessingland deposit," also as "the Mammalian-bed of Kessingland," etc., and treat it, in a great measure, as a deposit *peculiar to the Kessingland Cliff-section;* but I would draw attention to the fact, that the continuation of this very same deposit is to be seen at the base of the adjoining cliffs of Hopton and Corton, containing rootlets of the same kind and in precisely the same crumpled condition as those to be seen at Kessingland and Pakefield; and the deposit of clay itself—in which the rootlets occur in a vertical position as they grew—is in every respect precisely similar to that at Kessingland, and likewise contains Mammalian remains. I have also observed this same deposit, with rootlets, in the Cliff-section at Hasborough,[1] and also in the Cliff-section at Runton, to the west of Cromer; and have not the slightest doubt as to the identity of this remarkable bed—specially characterized by small vertical crumpled rootlets *in situ*, all apparently of the same species—which is exposed at intervals at the base of the Norfolk and Suffolk Cliffs, from Kessingland to Runton, a distance of nearly fifty miles; thus, marking an horizon of considerable importance with respect to the correlation of the beds in Norfolk and Suffolk: and this horizon, I may briefly explain—as all details will be given in future Survey memoirs and cliff-sections—occurs at the upper part, or thereabouts, of what is generally known as the Cromer preglacial Forest-bed series, and *beneath* the Lower Glacial series of Messrs. Wood and Harmer.

Although, according to Mr. Harmer, there is nothing in the Kessingland Cliff-section to show whether this deposit, with rootlets, preceded the Lower Glacial beds, that is not the case in the other cliff-sections mentioned by me, where a continuation of this identical deposit with rootlets occurs; at Hopton and Corton it is overlaid by the Contorted Drift or Lower Boulder-clay, with a few feet of buff-coloured sand and laminated grey clay in places intervening; at Hasborough—where the deposit itself is contorted together with the rootlets—it is overlaid by Cromer Till, which latter, close by, is underlaid by a little buff-coloured sand and laminated grey clay; and at Runton it is overlaid by twelve to fifteen feet of buff-coloured sand—in which is some gravel and laminated grey clay—which latter underlies the Cromer Till and Contorted Drift. Thus, by the best of all geological evidence, namely, superposition, it is perfectly clear that this Mammalian deposit, with rootlets, did *precede* the Lower Glacial beds: therefore, it is not of interglacial age as suggested, cautiously I admit, by Messrs. Wood and Harmer, and consequently will not in any way support their views of East Anglian interglacial valley excavations.

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[1] Spelt Happisburgh on Ordnance Map; but usually called Hasborough.

It is well known that Messrs. Wood and Harmer have long been sceptical as to the Forest-bed series at Kessingland—owing, I presume, to certain complications in this cliff-section—being of the *same age* as the Forest-bed series of the Cromer coast; and, I think I am correct in stating, that, in their numerous publications, they have entirely ignored the existence of the Forest-bed series at Hopton and Corton, which, in my opinion, forms a very important link in the series, inasmuch as that deposit, as I have already stated, is identical in every respect with the Rootlet-bed of Kessingland, to the south of it, and to that of Hasborough to the north of it. Mr. Gunn, on the contrary—from the evidence of the Mammalian remains, associated *Unio*-beds, etc.—has long held the opinion that the Kessingland Forest-bed series belonged to the *same series* as that of the Cromer coast, the correctness of which opinion my investigations fully confirm.

As I have used the terms "Lower Glacial series" and "Forest-bed series" in this communication, I wish particularly to state, I do not necessarily adopt all the views of the authors of those terms respecting the beds included by them in these series; and as I hope to treat of the relation of the Forest-bed series to the Chillesford Clay in some future paper, I have not referred to that subject here.

III.—ON THE SUCCESSION AND CLASSIFICATION OF THE BEDS BETWEEN THE CHALK AND THE LOWER BOULDER-CLAY IN THE NEIGHBOURHOOD OF CROMER.

By CLEMENT REID, F.G.S.;
Of the Geological Survey of England and Wales.

BY the permission of the Director-General of the Geological Survey I am enabled to publish a short account of the results arrived at during a detailed examination of the cliffs between Weybourn and Mundesley on the coast of Norfolk.

In the course of the Survey I have found it necessary to make considerable alterations in the generally accepted classification and succession of the Pliocene beds near Cromer, while my views with regard to the mode of formation of the so-called "Forest Bed" differ materially from those published by previous observers. To show clearly the changes which occur in these beds I will describe each one separately, commencing at the base.[1]

WEYBOURN BEDS AND FOREST BED.

Beds of sand with numerous seams of clay and an abundance of shells are shown resting immediately on the Chalk at Weybourn. These constitute the well-known "Weybourn Sands" with which Messrs. Wood and Harmer correlate the upper shell-bed of Belaugh, Wroxham, and other places in the Bure Valley. It will be desirable to retain the name "Weybourn Beds," as, besides being already known, they have the advantage at Weybourn of not occurring, as is the case in the Bure Valley, in proximity to any other marine and shell-bearing sands. The shell-beds at Weybourn vary in number, but careful collecting from each separately has convinced me that they all belong to one palæontological division. As these beds are traced towards Cromer, the upper portion becomes more and more interstratified with clay, which gradually takes the well-laminated character which is so conspicuous near Mundesley.

At Runton, resting directly on the Chalk, there is a bed of sand and nearly unworn flints full of double valves of *Mya arenaria* and *Tellina obliqua*; this is succeeded by two or three feet of marine crag, the upper part of which is mixed with land and fresh-water shells, and occasionally contains large bones. From this bed I obtained the scapula of an elephant now in the Museum of Practical Geology. Above this "Elephant-bed" is the "Forest-bed," consisting of a large quantity of drift wood, one tree trunk which I measured being upwards of 18ft. in length. This locality has yielded no leaves or seeds, and all the wood is much worn: a few marine shells occur with the wood. The Forest-bed passes up into laminated clays, seams of gravel cemented with iron locally known as "pan,"[2] and sands with marine fossils. The shells correspond with those in the lower bed, but the list, owing principally to the fewer and smaller exposures, is not yet so large. From Runton the Forest-bed thickens to the S.E., and as it increases the sands are replaced by laminated clays, and marine shells become scarcer, although they are still to be found at Mundesley and Bacton. The underlying shelly crag can be traced as far as Sidestrand, beyond which place the foreshore is nearly always hidden by sand.

The usual character of the Forest-bed is well exhibited on the foreshore opposite the Cromer lighthouse, where it consists of masses of drifted peat, wood, and stools of trees imbedded in greenish sand, with layers of clay pebbles. The well-known Mammalian remains occur in the sandy and gravelly beds, and, although not worn, they are commonly broken.

I have examined most of the localities where the "Forest-bed" has been seen as far eastward as Bacton, and have pulled up every tree-stump that I could discover on the foreshore. The roots always exhibited a worn and frayed-out appearance, and did not end in rootlets, as published descriptions would lead us to expect. It is not sufficient to find stools of trees in any upright position, as when laden with earth and stones they would naturally sink with the roots downwards. It is possible that hidden in some part of the beach there *may* be a submerged forest that I have not yet seen, but the masses of drift wood already described are what Norfolk geologists speak of as the "Forest-bed." I am informed that Mr. Norton, of Norwich, has communicated a paper to the Norwich Geological Society, expressing his opinion that none of the stools of trees he has observed at Mundesley have grown on the spot.

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[1] Detailed descriptions of the sections and complete lists of fossils will be given in the Survey publications.

[2] Pan occurs at various horizons.

From the facts I have been enabled to gather, I have been led to regard the "Forest-bed" as an estuarine equivalent of the upper part of the marine Weybourn Beds, and not as a land surface.

From the lower marine bed at Runton I have obtained the following species, most of the land and fresh-water species only occurring with the bones:

c. common. r. rare. v.c. very common. v.r. very rare.

Buccinum undatum, v.r.
Helix arbustorum, r.
———— *hispida*, v.r.
Limnæa palustris, v.r.
Littorina littorea, v.c.
———— *rudis*, r.
Melampus pyramidalis, v.r.
Natica catena, c.
———— *clausa*, v.r.
———— *helicoides*, r.
Paludina vivipara, 1.
————? *glacialis*, 2.
———— *media*, 2.
Planorbis corneus, 1.
Pleurotoma turricula, r.
Purpura lapillus, v.c.
Scalaria Grœnlandica, c.
Succinea putris, 1.
Trophon antiquus, v.r.
———————— (reversed var.), r.
Turritella terebra, v.r.

Astarte borealis, v.c.
———— *compressa*, c.
———— *sulcata*, r.
Cardium edule, v.c.
———— *Grœnlandicum*, v.r.
Corbula striata, r.
Cyprina Islandica, v.c.
Donax vittatus, r.
Leda oblongoides, c.
Lucina borealis, v.r.
Mactra ovalis, r.
* *Mya arenaria*, v.c.
———— *truncata*, v.r.
* *Mytilus edulis*, c.
Nucula Cobboldiæ, c.
† *Pholas crispata*, c.
Saxicava arctica, r.
Tellina Balthica, v.c.
———— *lata*, v.r.
* ———— *obliqua*, v.c.
———— *prætenuis*, 1.
Unio pictorum? 1.

* In their natural position with the valves united.

† In their borings about six feet above the present high-water mark near Sherringham.

I have as yet been unable to obtain any additional species from other sections on the coast; but I should mention that Prof. Prestwich's list contains *Venus fasciata* from the lower, and *Leda lanceolata* from both upper and lower beds at Weybourn. *Leda oblongoides*, which is not contained in Prof. Prestwich's list, is rather common; but I cannot find *L. lanceolata*, although I have repeatedly searched for it.[1]

The mineralogical character and fossils of the beds just described point to an estuary advancing seaward in a northerly direction. The relation of the sea-level to that of the land differed probably about

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[1] Quart. Journ. Geol. Soc., Nov. 1871.

20ft. from what it is at present, which (if we consider the fall of the tides to be unaltered) would bring the colonies of *Mya arenaria*, *Mytilus edulis*, and *Tellina obliqua* to a few feet below low-water, while *Pholas crispata* would occur between tide marks. Although *Tellina obliqua* and *T. Balthica* occur with the valves united at Weybourn at a higher level, yet here they are not in their natural position, and the beds appear to have formed a sandy and muddy beach such as is often seen at the mouths of rivers.

FRESH-WATER BED.

Above, and often resting on a slightly eroded surface of the marine and estuarine beds already described, are shown extensive deposits of freshwater sand, clay, and peat. These beds are much more extensive than is commonly considered, and appear to have been formed in shallow lakes like the present "broads" of Norfolk. They can be traced with but short interruptions from Weybourn to West Runton, and again from Overstrand to Mundesley.[1]

In places rootlets penetrate three or four feet into the Weybourn Beds, marking the position of islets in the lakes, or perhaps belonging to water-plants, in which case they would indicate where the fresh-water deposits have been denuded. This "rootlet bed" may be traced at intervals between Happisburgh and Weybourn Signal Station, but the rootlets do not always penetrate beds on the same horizon.[2] It is noticeable that none of these roots belong to anything larger than brushwood, as observed by Mr. Gunn in a similar bed at Kessingland.

The Fresh-water Bed appears to have been formed when the relations of sea and land were much as they are at present, for although in several places between Sherringham and Mundesley it has filled hollows a foot or two below high-water mark, the channels seem never to be cut deeper, apparently showing that they had reached the sea-level.

The mammals from this bed have been carefully collected at West Runton by Mr. A. C. Savin, and the list already contains two or three species not known in the Forest-bed. It has also yielded the wing-bone of a bird, seeds, beetles and numerous mollusca. From this locality I have obtained the following species of land and fresh-water shells :—

Paludina contecta.
——— *vivipara.*
Valvata piscinalis.
——— *cristata.*
Bythinia tentaculata.
Planorbis albus.
——— *complanatus.*
——— *contortus.*
——— *corneus.*
——— *nautileus.*
——— *spirorbis.*

Limnæa palustris.
——— *peregra.*
——— *stagnalis.*
——— *truncatula.*
Ancylus lacustris.
Limax, 2 sp.
Succinea putris.
Helix arbustorum.
——— *hispida.*
——— *nemoralis.*
Zua lubrica.

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[1] It should be remembered that there are two fresh-water beds at Mundesley, one older than the Lower Boulder-clay, the other newer, and probably Post-glacial.

[2] Near Weybourn, where the Fresh-water Bed rests directly upon the Chalk, the joints and crevices in this rock are often filled with peat.

Pupa, sp.
Carychium minimum.
Clausilia, sp.
Corbicula fluminalis.
Sphærium corneum.
Pisidium amnicum.
——— *fontinale*, var. *Henslowana.*
——— *pusillum.*
Unio pictorum.
Anodon cygneus.

To the above list may be added *Physa fontinalis* and *Planorbis nitidus* from specimens in the Norwich Museum. I have been unable to find *Unio margaritiferus* and *Pisidium nitidum* mentioned in Prof. Prestwich's paper (*op. cit.*).

None of the shells are stunted, and the whole assemblage, with the exception of *Corbicula fluminalis*, is such as might now be found in the Norfolk broads. There appears to be no sufficient reason for classing either this or the Weybourn Beds with the glacial series, for the climate, as shown by the land animals and plants, was but little, if at all, colder than at present. The first appearance of *Tellina Balthica*, so much relied upon by Messrs. Wood and Harmer, seems hardly of sufficient importance, in the absence of other evidence, to mark the incoming of the Glacial Period, for it is now living on our coasts, and is by no means a peculiarly arctic shell.

MYALIS BED.

We now arrive at beds which show a decided change of conditions, for directly over the fresh-water deposits and usually separated from them by a marked line, occur fine false-bedded sands with gravel and loam, the fossils of which would have lived in a depth of five or ten fathoms. These sands, for which I propose the name of *Myalis Bed*, from their being characterized by the presence of *Leda myalis*, are very sparingly fossiliferous; but where fossils do occur, they form colonies, with the bivalves in their natural position. I have been unable to adopt Prof. Prestwich's name of "Westleton Beds," as the shingle at his typical locality is unfossiliferous, isolated, and is not seen in connexion with either the Fresh-water Bed or the Contorted Drift. His fossils were obtained from the Weybourn and Fresh-water beds, with the exception of *Leda myalis* and *Mya truncata*, obtained from West Runton.[1]

This bed has already yielded the following species, and I hope in time to add more:—

Buccinum undatum, r.
Lacuna, sp., v.c.
Littorina littorea, c.
„ *rudis*, v.r.
Natica, sp., v.r.
Purpura lapillus, r.
Trophon antiquus (reversed var.), r.
* *Astarte borealis*, r.
Cardium edule, r.
* *Cyprina Islandica*, v.c.
* *Leda myalis*, v.c.
* *Mya truncata*, v.c.
Mytilus edulis, r.
* *Ostrea edulis*, v.c.
Tellina Balthica, c.

* In their natural position with the valves united.

A careful examination of the junction of the Myalis Bed with the

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[1] When on a visit to Westleton last year, my colleagues, Messrs. H. B. Woodward and J. H. Blake, ascertained that the shingle at that locality was the equivalent of masses of shingle that occur in the so-called Middle Glacial Sands of Dunwich Cliff.

er Boulder-clay has always
n me a sharp and well-
ed line of division, and
er Mr. H. B. Woodward nor
lf have been able to see
alternation of these sands
the Cromer Till, such as
entioned by Messrs. Wood
Harmer as exhibited in the
lk cliffs.[1] For this reason,
on account of the absence
acial action (other than per-
that of river ice) in any
e beds described, I have
ht it advisable to draw the
marking the commencement
e Glacial Period at the base
e Lower Boulder-clay—a
which I may mention has,
ndependent evidence, been
by Mr. H. B. Woodward
e neighbourhood of Norwich.
e subjoined table will show
ifferent stages of what may
ell termed the Norfolk Crag.

Boulder clay. — Contorted Drift and Cromer Till.

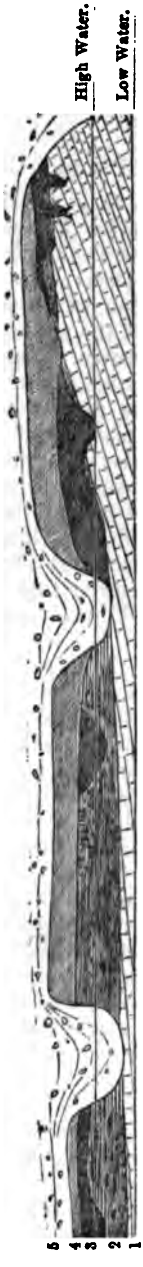
lk Crag:
- Myalis Beds.
- Freshwater Bed.
- Weybourn Beds and Forest-bed.
- Chillesford Crag.[2]
- Norwich Crag proper, or Fluvio-marine Crag.[2]

e accompanying section will
the relations of the several
ions of the Pliocene Strata in
liffs between Sidestrand and
bourn. The Glacial Beds,
the exception of part of the
er Boulder-clay, are omitted,
y could not be shown on the
erated scale in the right
rtion to the other strata. It
be observed that the Lower
ler-clay occasionally scoops
to the Chalk, as at Beeston.

DIAGRAM SECTION TO SHOW THE RELATIONS OF THE PLIOCENE BEDS BETWEEN SIDESTRAND AND WEYBOURN.

(Distance 10 miles; vertical scale highly exaggerated. The upper portion of the cliff not shown.)

E. W.



EXPLANATION OF SECTION IN DESCENDING ORDER.

5. Lower Boulder-Clay.
4. Myalis Bed.
3. Freshwater Bed.
2. Weybourn Sands and Forest Bed.
1. Chalk with pockets of Peat near Weybourn.

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[1] pp. to Crag Mollusca, Introduction, p. xviii.
[2] ot shown in the Cromer Cliffs.

IV.—FURTHER CONTRIBUTIONS TO BRITISH CARBONIFEROUS PALÆONTOLOGY.

By ROBERT ETHERIDGE, Junior, F.G.S., etc.

(*Continued from the June Number*, p. 251.)

(PLATE XIII.)

Class PISCES. Genus FISSODUS, St. John and Worthen, 1875.

Fissodus, St. J. and W., 1875. Illinois Geol. Report, vol. vi. p. 413.

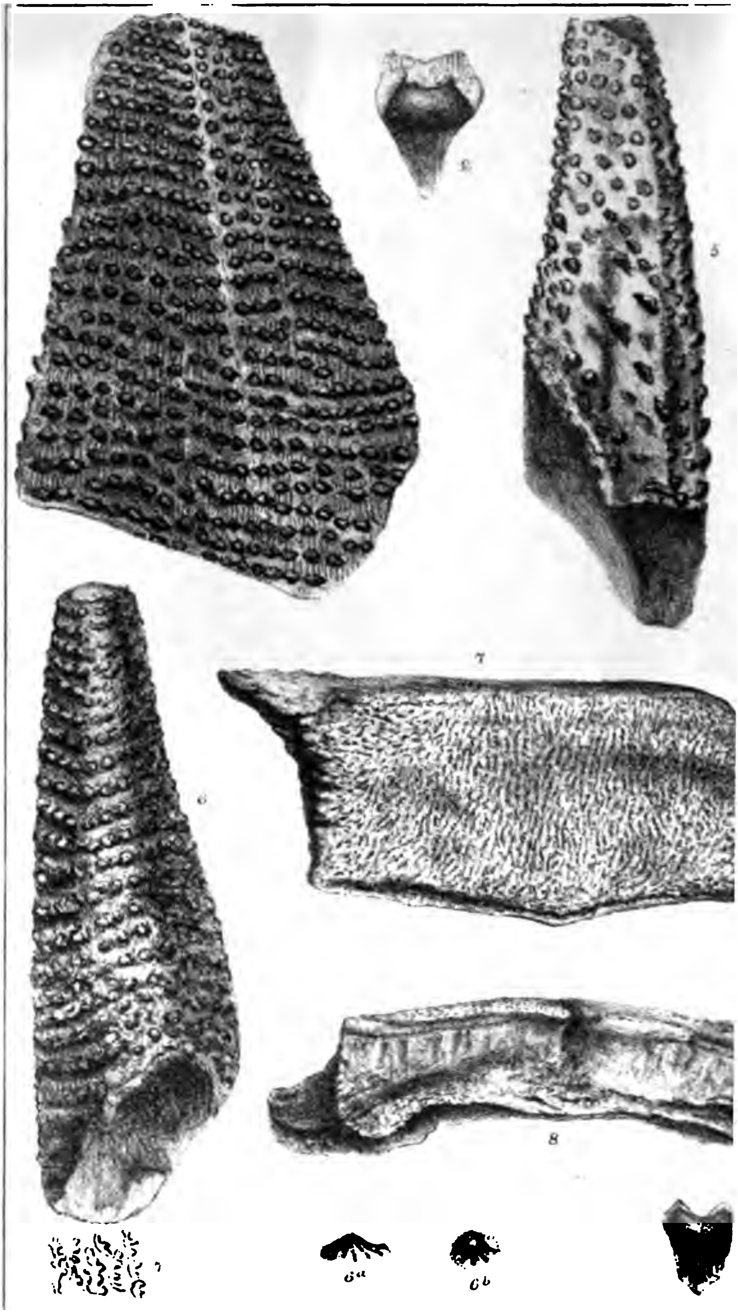
Fissodus Pattoni, sp. nov. Plate XIII. Figs. 2 and 3.

Sp. Chars.—Tooth bidenticulated with a re-entering angle between the denticles; sides sloping down to the lateral angles; anterior profile convex; posterior profile concave. The most prominent portion of the anterior surface is at the centre of the inferior margin of the crown, where it becomes bowed-out, whence the surface gradually recedes to the cutting edge of the crown on the one hand, and more rapidly towards the root on the other. Superior and inferior margins of the crown symmetrical; no coronal ridges on the anterior; anterior surface of the crown smooth, but, where worn, with a coarsely-fibrous appearance. On the posterior face of the tooth the enamel-like layer only just caps the two denticles, and is traceable as a thin line into the re-entering angle between them, and are bounded inferiorly by a thickened ridge; the convex portion of the anterior face is here represented by a concavity. Root long, attenuated, or oblong.

Obs.—I believe it is now becoming generally acknowledged that many of the so-called species amongst the Carboniferous "palatal" teeth are mere variations of other well-marked forms. Notwithstanding this, I think we are justified in assigning names, provisionally at any rate, to teeth which appear to be different from those already known, until such can be shown to be individuals of a series represented by some previously well-known form. Acting under this belief, I have given the above name to the elegant little tooth now figured, in honour of Mr. A. Patton, to whom I have been frequently indebted for the loan of fossils from his cabinet. My friend, Mr. W. Davies (of the British Museum), was kind enough to examine and compare one of the specimens with the extensive collection of teeth in the National Collection, and informs me that it is unknown to him.

I believe I am correct in referring them to the above recently established genus, although one of the characters ascribed to *Fissodus*, viz. the ear-like lateral angles, is certainly not represented here, the latter being definitely rounded. Of the two described species, *Fissodus bifidus*, St. J. and W., and *F. tricuspidatus*, St. J. and W., our tooth very closely resembles the former; but there is the partial generic difference noticed above, and there is an entire absence of imbricating ridges at the base of the crown, in addition to other minor points.

Loc. and Horizon.—Obtained by Mr. A. Patton from shale immediately above the Calderwood Cement Stone, Lower Carboniferous Limestone Group, at the Kirktonholm Cement Mine, East Kilbride, Lanarkshire; also roof of the Splint Coal, Edge Coal Series, Dean



Ichthyodorulites Carboniferous
Scotland

, Kinniel, near B'oness.—Collection of the Geological Survey of ıtland, collected by Mr. James Bennie.

Genus ORACANTHUS, Agassiz.

Oracanthus Milleri, Agassiz. Plate XIII. Figs 4–6.

Milleri, Ag.; Rech. Poissons Foss. vol. iii. (1833-34), p. 13, Atlas iii. t. 3, f. 1-4.
„ M'Coy, Brit. Pal. Foss., p. 634.

Spine.—Four-sided, more or less laterally flattened, tapering, hollow ırly to the apex, substance thin. Apex where broken = 10 lines 4½ lines; base = 2 inches 2 lines by 1 inch (about). Section of base transversely oval; section of the apex oval, wider at one l than the other, solid. Anterior end (?) narrower than the ıterior; posterior end (?) flattened, at right angles to the sides. ıal large, occupying the whole of the internal portion of the , but terminating towards the apex at the fractured point. Sur- e covered with conical, fluted tubercules, arranged singly in lulating transverse ridges or becoming laterally confluent; ces of the tubercules obtusely pointed. On one of the larger lateral faces the rows are almost horizontal, or only slightly ique; but on the other they are much more so, the obliquity ng considerably increased on the smaller ends. The tubercules rease slightly in size down the spine from the apex towards base, and their apices are, if anything, inclined a little upwards rards the former; on the flattened posterior (?) end they are idedly larger than on any other part of the spine. The confluent tions of the ridges are of less height than the tubercules them- ves. Flattened, or a little concave, striate, or striato-punctate ces separate the transverse ridges.

Obs.—The protean character of surface ornamentation, proportions, l distortion often found in this spine are ascribed by Prof. M'Coy[1] the thin character of its substance, and in consequence no two criptions will be found alike. M'Coy united Agassiz's described m *O. Milleri* with the undescribed *O. confluens*,[2] and doubtless h justice. The above description is that of the very handsome cimen (Figs. 4–6) from the Cabinet of Mr. A. Patton, E. Kilbride, l which appears to be *O. Milleri* (+ *O. confluens*), as described by f. M'Coy. Dr. Traquair was kind enough to examine a specimen ring the name *O. confluens*, in the Cabinet of the Earl of niskillen, and informs me, that, so far as he can recollect, hout actual comparison, Mr. Patton's fine specimen bears a great emblance to it. The spine appears to be quite in its normal m, there are no signs of crushing or distortion. The free, or con- ent form of the tubercules, is not specially confined to any one t of the spine.

Loc. and Horizon.—Obtained by Mr. A. Patton from shale two feet l a half above the Calderwood Cement Stone. Lower Carboniferous nestone Group, in a quarry at the Upper Gliebe, East Kilbride, ıarkshire.

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[1] *Loc. cit. suprà.*

[2] *Loc cit. suprà*, p. 177.

Genus Psammodus, Agassiz.

Psammodus rugosus, Agassiz. Plate XIII. Figs. 7–9.

P. rugosus, Ag.: Rech. Poissons Foss. vol. iii. (1833-34), p. 111, Atlas iii. t. 12, f. 14-18, t. 19, f. 15.
" " M'Coy, Brit. Pal. Foss., p. 644.

Tooth.—Oblong, lingual; length, without the lateral prolongation, 2 inches 5 lines; breadth 1 inch 2 lines; height 8 lines. The longer margins of the crown are convex and rounded, with sharp edges, and bound the somewhat concave centre of the crown, which is higher in the middle than at the shorter ends. One of the shorter margins (the anterior?) is obliquely convex, and its edge roughly crenulated; the other (or posterior?) is somewhat concave or excavated, with the edge a little bevelled outwards and deeply slit vertically. *Sides.*—The longer sides are more or less vertical, or at right angles to the crown; one of the shorter sides (the anterior?) is bevelled inwards for the articulation of the preceding tooth; the other shorter side is like the longer lateral ones, almost vertical, and is extended backwards with one of the latter to form a pointed, laterally compressed prolongation. *Ornamentation.*—The crown is covered with minute, vermiform, transverse, tortuous fringed ridges, many of which bifurcate, and become more broken up on the longer lateral margins. The longer lateral sides are roughened.

Obs.—The present tooth differs from Agassiz's typical figures in the absence of the prominent rounded eminence on the posterior part of the crown, although one of his specimens appears to have been devoid of it. Agassiz considered that an intimate affinity existed between the teeth he named *P. porosus* and *P. rugosus*, whilst about 50 or 60 feet below the bottom of the Orton Scar Limestone at Ashfield, Ravenstonedale, Westmorland. Associated with the tooth, Prof. Nicholson informs me, were a large number of Corals, Brachiopods, and other fossils. Of the Corals the most characteristic and abundant were *Lithostrotion Martini*, *L. irregulare*, *Syringopora geniculata*, and *Zaphrentis Bowerbanki*. Cabinet of Prof. Nicholson.

I am much indebted for information and the loan of specimens to Professors Williamson and Nicholson, and Messrs. E. W. Binney, F.R.S., A. Patton, J. Bennie, J. Linn, and J. Simpson, and the Rev. T. Brown, M.A.

EXPLANATION OF PLATE XIII.

FIG. 1.—*Dentalium inornatum*, M'Coy? twice nat. size. L. Carboniferous, Ardross, Fife. Coll. Geol. Survey, Scotland.
„ 2.—*Fissodus? Pattoni*, R. Eth., jun.; three times nat. size. Calderwood Series, East Kilbride. Cabinet of Mr. A. Patton. Anterior view?
„ 3.—The same; another specimen, posterior view? three times nat. size. Roof of the Splint Coal, Edge Coal Series, Dean Pit, Kinneil, near B'oness, Linlithgowshire. Coll. Geol. Survey of Scotland.
„ 4.—*Oracanthus Milleri*, Ag. lateral view, nat. size. Calderwood Series, East Kilbride. Cabinet of Mr. A. Patton. 4*a*, tubercules enlarged.
„ 5.—The same; posterior view? nat. size.
„ 6.— „ anterior „ „
„ 7.—*Psammodus rugosus*, Ag. var.; view of crown of the tooth, nat. size. Carboniferous Limestone, Ravenstonedale, Westmorland. Cabinet of Prof. Nicholson.
„ 8.—The same. Side view showing the lateral prolongation; nat. size.
„ 9.—Portion of surface of the crown of the same tooth magnified to show the characteristic "fringed ridges."

V.—On the so-called "Permian" and the New Red Sandstone Formations.

By the Rev. A. Irving, B.A., B.Sc., F.G.S.,
of Wellington College, Wokingham.

On the 6th March, 1874, I communicated a paper on the "Geology of the Neighbourhood of Nottingham"[1] to the Geologists' Association, which was subsequently printed *in extenso* in their Proceedings. Up to that time I believe the definition laid down by the Government Survey, and imported into text-books, of the distinction between the so-called Permian and the New Red Sandstone formations had not been called in question very prominently. Like other students of geology, I myself accepted in good faith the *dictum* as to a great break existing between the two formations, indicating, of course, an enormous period of time. I could not, however, help, as I walked along the banks of the Leen,—which flows along the foot of the western escarpment of the Lower Bunter Sandstone,—trying to realize what this really meant; and the thought was not without its influence in stimulating me to try and work out such evidence as the district might afford, of the reality of this great hypothetical interlude in the geological succession of strata. Wishing to make myself acquainted with all the observations which had been previously made upon the subject, I perused carefully the memoirs of the Geological Survey upon the district. The more the matter was studied, the more did I lose confidence in the dictum above referred to, and I could not help coming finally to the conclusion, as Prof. Phillips had done, with reference to the same two series of rocks in another area, that "their physical history was upon the whole *one* great series of natural operations." Nor had I overlooked, as Mr. Aveline[1] seems to imagine, the few and meagre data which were furnished by him and by Prof. Hull in their respective "Memoirs," from which their conclusions as to the great unconformity between Bunter and Permian was drawn. It is not for me to point out to Mr. Aveline, or to any other geologist so practised and experienced in field-work as he is, that we have here a question where we must decide, if at all, by the balancing of probabilities. The *direct* evidence of any great unconformity is very weak indeed. The intercalation of the middle marls and sandstones by Worksop and northward furnishes very little proof of the removal by post-Permian denudation of the Upper Magnesian Limestone as we proceed south; as I think any one will see who will take the trouble to weigh well the reasoning of Mr. E. Wilson, F.G.S., in the May Number of this MAGAZINE (p. 238). I must say that I agree with this gentleman entirely as to the true interpretation of the facts reiterated with so much emphasis by Mr. Aveline in his recent communication to this periodical: facts which both Mr. Wilson and myself were fully conversant with, since they were stated years ago in the "Memoirs." And not only are we now in a better position to judge of their true bearing, on account of the great accession to our stock of data which has been furnished by the recent development of the South Notts Coal-field; but I venture to say that any one who had seen the great intercalated masses of dolomitic sandstone which are quarried in the neighbourhood of Mansfield, might well feel sceptical (in the absence of palæontological evidence) as to the precise identity of a particular member of the Magnesian Limestone group at Worksop, with the beds that occur between Mansfield and Nottingham; where the lateral variation of the whole series is so great, and the general tendency of even the dolomite itself to become more and more coarse-grained, flaggy, and gritty in its progress southward, is most pronounced. Nor do I forget (even with the circumscribed geological vision of a "local geologist") that this is in general harmony with the thinning-out of the whole series of the Magnesian Limestone from a thickness of 600 feet in the county of Durham, to that of a few flaggy bands in Nottinghamshire.

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[1] See Geol. Mag. 1874, New Series, Vol. I. p. 314.

Every one who has done any field-work at all, must know how hazardous it is to generalize in a spirit approaching to anything like dogmatism, on the actual relation of two sets of rocks, both of which are unfossiliferous, unless they had been *traced continuously across the country;* and this Mr. Aveline, with the small amount of data afforded, will scarcely maintain to have been done in the present instance. That a southern and south-western boundary must have existed somewhere to the Magnesian Limestone Sea, is beyond all doubt; and we believe that it was not far from the latitude of the town of Nottingham; for I suppose no one will contend that the Permian series of this district has anything in common with, or was once continuous with, the so-called Permian sandstones and marls of Warwickshire and the adjacent counties (which, by the way, I am glad to learn that Mr. Aveline is willing to relegate to the Coal-measures, and so confirm the belief to which a visit of two or three weeks of last winter to that county, led me).

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[1] See Mr. Aveline's article in the April No. of GEOL. MAG., p. 165, "On the Magnesian Limestone and the New Red Sandstone of Nottingham."

It is with great diffidence now, as it was four years ago, that I venture to discuss with him a question for which he has so much more aptitude, both from extensive observation and from professional training, than one can possibly pretend to, who has worked at Geology more from a conviction of its educational value than from any other motive: but I hope he will pardon my saying that in geological questions we must look for the same logical coherency in the evidence as we demand in other departments of science or in a court of law, and that the lack of this cannot be compensated for by our belief (however strong that may be), in the extensive knowledge of the observer. That the Bunter strata overlap the Magnesian Limestone in Nottinghamshire is evident enough, but I could not see (nor can I see yet) that this *necessarily* implies unconformity resulting from the disturbance and general denudation of the immediately subjacent strata. This may or may not accompany the phenomenon of "overlap"; and whether it actually does or not must be decided, in a case like the present, by examination of actual sections; but here we find, as section after section is added to the list of those previously exposed, that the great break (as evidenced by *observed* unconformity) is *below* the "Permians," and not above them. I do not for a moment maintain that there is "perfect conformity" everywhere between the Permians and the Bunter; but I believe that such slight unconformities as are actually observable at this particular horizon are not a whit greater, and have no more *general* significance whatever, than such as (according to my own observation. and Mr. Aveline's showing in his 'Memoir') exist between different members of the Permian and Trias themselves; and especially (*a*) between the Magnesian Limestone and the stratified red and purple *Permian* marls that lie upon its eroded surface at Mansfield and elsewhere; (*b*) at the junction of the Lower Mottled Sandstone and the base of the Bunter Conglomerates, as seen in section in the "Hemlock Stone"; (*c*) at the junction of the Bunter and the Keuper, several sections of which in the neighbourhood of Nottingham I have previously described. For further information concerning such minor and localized unconformities, I may refer to Mr. Aveline's memoir on "Parts of Nottinghamshire and Derbyshire," p. 11, and to Prof. Hull's memoir on the "Permian and Triassic Rocks," figs. 11, 12, 13, 14, and 16.

It is no reflexion upon Mr. Aveline personally, nor in any sense a depreciation of the officers of H.M. Geological Survey or their most valuable work, to suggest that generalizations may have been, in freshwater and marine: the other is the further subdivision of the lower or marine portion into two by uniting the Ganister Beds, Millstone Grit and Upper Limestone Shales into a Middle division, and the Carboniferous Limestone and Lower Limestone Shales into a Lower division.

It is difficult to see how the Lower Coal-measures and the Millstone Grit can properly be classed as *essentially* marine in the face of the coal-seams and beds of Ganister, which bespeak land-surfaces: but the proposal to unite the Lower Coal-measures or Ganister Beds with the Millstone Grit has something to recommend it, for the North of England at least, on stratigraphical grounds beyond the palæontological ones relied on by Prof. Hull: for the two sets of beds have much in common; workable coal-seams are not unknown in the Millstone Grit of Derbyshire, and such become more common as we go northward; though the Sandstone Beds are as a rule coarser in the Millstone Grit than in the Lower Coal-measures, yet all Millstone Grits are not coarse; some are very fine; and grits quite as coarse as ordinary Millstone Grits do occasionally occur in the Lower Coal-measures. It is true we have a well-marked top to the Millstone Grit in Derbyshire and Yorkshire: but this I look upon as a happy accident: and were the Permian removed, where it hides the upper part of the Millstone Grit, perhaps we should find the Rough Rock lose its well-marked character or possibly thin away altogether, and then where would our division-line be? But, what is more important, beds of Ganister, which are *the* distinguishing feature of the Lower Coal-measures, occur also in the Millstone Grit: this is the case as far south as Derbyshire; and as we go north the Ganister beds in the Millstone Grit become so prominent that the measures containing them might easily be mistaken for the equivalents of the Lower Coal-measures of South Yorkshire.

Prof. Hull further proposes to class the Upper Limestone Shales with the Millstone Grit. It has always been a difficult matter to separate these two subformations satisfactorily, except for quite limited areas. The line between the two has been drawn in very different places by different observers. The late Prof. Phillips drew the line below the great grit of Pendle Hill: subsequent observers threw the equivalent of this grit, under the name of Yoredale Grit, into the Upper Limestone Shales. But Phillips was undoubtedly right in classing it with the Millstone Grit; for the grit in question is simply the basement bed of the Kinderscout Grit, from which it is often quite impossible to separate it satisfactorily. The name Yoredale Grit, too, is a singularly unhappy one; for it is more than doubtful whether any representative of this grit occurs in Yoredale at all. But in my opinion the term Yoredale, as a synonym for the old term Upper Limestone Shale, is itself incorrect. The type of beds developed in the valley of the Yore is a very marked one; also very peculiar, by no means generally characterizing the beds below the Millstone Grit; it would seem better therefore to retain the old term Upper Limestone Shales for these measures generally, reserving the term Yoredale series for those cases in which the beds approximate more or less to the type in Yoredale. Considering the peculiar character of the Yoredale beds, so different from the Millstone Grit, I think it would be a mistake to throw them into the same class as the latter group; nor would Prof. Hull find it everywhere so easy, as it is in Derbyshire and Lancashire, to separate the Upper Limestone Shales from the Carboniferous Limestone, the fact being that the thick limestone splits up north-eastward into a number of subdivisions of limestone, sandstone, and shale. I do not myself believe, *pace* Prof. Hull, in the possibility of finding any classification of the Carboniferous rocks applicable to the whole of England, other than the philosophical one recommended by Prof. Ramsay, of treating the whole as one indivisible formation and mapping separately each important bed, or group of beds, of grit, limestone, chert, ironstone, plate, or shale.

VII.—MESOZOIC VOLCANIC ROCKS OF BRITISH COLUMBIA AND CHILE. RELATION OF VOLCANIC AND METAMORPHIC ROCKS.

By GEORGE M. DAWSON, F.G.S.,
of the Geological Survey of Canada.

IN Chile and adjacent regions of South America, Mr. Darwin, in his "Geological Observations," has described a great series of Mesozoic rocks, which he calls the "porphyritic formation," and which shows an interesting resemblance to certain rocks in British Columbia. These I had provisionally designated in my report in connexion with the Geological Survey of Canada for 1875, as the *Porphyrite series*, without at the time remembering Mr. Darwin's name for the Chilian rocks. Many of Mr. Darwin's descriptions of the rocks of Chile would apply word for word to those of British Columbia, where the formation would also appear to bear a somewhat similar relation to the Cascade or Coast Range, which that of Chile does to the Cordillera. By its fossils, the porphyritic formation of Chile is proved to occupy a position intermediate between the Jurassic and Cretaceous, which is much that which the Porphyrites of British Columbia must hold. Beds overlying the Porphyrites on Tattayoco Lake by some thousands of feet—probably conformably—hold fossils characteristic of the Shasta Group or lowest of the Cretaceous in California, which is believed to represent the English Series from the Gault downwards. Fossils collected last summer in the porphyrite and felsite—altered ash rocks—of the Iltasyonco, a branch of the Salmon River in latitude 52° 50′, present a more distinctly Jurassic *facies*, though their palæontological value will be more certainly known when Mr. Whiteaves shall have finished his examination of them.

Of the South American Series Mr. Darwin writes:[1]— "The alternating strata of porphyries and porphyritic conglomerates, and with the occasionally included beds of felspathic slate, together make a grand formation; in several places within the Cordillera I estimated its thickness at from 6000 to 7000 feet. It extends for many hundred miles, forming the western flank of the Chilian Cordillera;

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[1] *Loc. cit.* p. 476.

and even in Iquique in Peru, 850 miles north of the southernmost point examined by me in Chile, the Coast escarpment which rises to a height of between 2000 and 3000 feet is thus composed."

The area over which the Porphyrite formation occurs in British Columbia is very great, but is as yet imperfectly defined. I have roughly estimated its thickness in one locality at not less than 10,000 feet. It is built up of porphyrites, tending occasionally towards quartz porphyries, felsites, and fine-grained dolerites, diabases, and probably also diorites, with other rocks transitional between these and the first named, and great masses of volcanic breccia or agglomerate. Many of these rocks are of sedimentary origin, as shown by their holding fossils, and by their bedding, but the material has been supplied ready made as volcanic ashes and sand, and in the region near the eastern flanks of the Coast Range no intercalated siliceous sandstones, or water-leached clays forming true argillites, are found.

It may seem hazardous even to compare rocks so widely separated in space, but it is very generally found that in directions parallel to the main axis of disturbance on the West Coast, the formations are remarkably constant in character, and it is just in such cases that lithological resemblances may to some extent safely supplement other facts. I am not aware that contemporaneous volcanic products have been recognized as forming a part of the Cretaceous or Jurassic formations of California,—which of the intermediate region is the most carefully studied portion,—but in reading Professor Whitney's report, one is much tempted to believe that a portion of the very puzzling appearance of metamorphism in certain groups of beds intercalated with others almost unchanged, may really be due to their original composition as volcanic materials easily hardened and crystallized. The "red rock" or "imperfect serpentine" of the Cretaceous of the vicinity of San Francisco certainly resembles nothing so much as a partly altered volcanic product.[1]

It is evident that by the folding together and complete metamorphism of such masses of volcanic material as those described in Chile and British Columbia, they would form, without addition or much chemical change, a great series of granites, gneisses, diorites, and crystalline schists, like those characterizing many of the older formations in portions of their extent. Besides the mere chemical identity rendering this change possible, it may, I think, be stated that the equivalency of volcanic products with rocks of this class has actually been demonstrated in the field. I would refer especially in this connexion to the work of Prof. Judd in West Scotland, and to that of Mr. J. Clifton Ward in Cumberland. In Vancouver Island, we have, in fact, also a great series of rocks of Palæozoic age, almost certainly referable to the Carboniferous period, which while composed of diorites, felsites, schistose and gneissic rocks which Mr.

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[1] It should be mentioned that Prof. J. J. Stephenson, in reporting on a portion of Colorado, speaks of "large fragments of volcanic rocks and volcanic ash in the lower portion of the Cretaceous everywhere." U.S. Geol. Surv. West of the 100th Merid., 1875, vol. iii. p. 500.

Selwyn has compared in their lithological character to those of the Huronian or Altered Quebec group of Eastern Canada, yet retain ample evidence of their origin as volcanic sediments and igneous flows, and hold some beds of crystalline limestone, and of argillite, —the *latter showing comparatively little sign of alteration.* It is not, however, intended at this time to enter into detail with regard to these rocks, or of the yet more ancient-looking diorites and granites of the Cascade Range, which are very possibly of the same age and origin.

Passing from rocks such as these, however, of which the source is yet clearly demonstrable, to some of those of the Eastern border of the Continent, one is led to think that sufficient prominence has not been given, in endeavouring to account for their origin, to the possible inclusion at different periods of great masses of little weathered volcanic products; and that while in Britain the importance of such material has been fully recognized, and it has been found to occur at many stages in the geological scale,—forming in Cumberland from 12,000 to 15,000 feet of "green slates and porphyries," in Wales a great thickness of similar hard and more or less crystalline rocks in the Lower Silurian alone,—it has scarcely been allowed a foothold in Eastern America except in instances so patent that to deny its origin would be absurd. In discussing the possibility of the production of "metamorphic" rocks from ordinary aqueous sediments not chemically their equivalents, by pseudomorphism and replacement, and the *chemical* formation of sediments by processes not active at the present day, much ingenuity has been employed, while the place of volcanos in supplying ready-made the material of crystalline rocks has virtually in too many cases been ignored. This action, according to strictly uniformitarian principles, must be supposed to have been at least as important at former periods as at present, and very lately the *Challenger* soundings have added largely to our idea of its influence, Mr. Murray having shown in connexion with them that in point of fact all deposits in the depths of the Pacific not organic are volcanic.

The rocks of the Huronian are, where I have studied them on the Lake of the Woods, I have no hesitation in affirming, in great part of volcanic origin; these beds, described originally by Dr. Bigsby as "Greenstone Conglomerates," being undoubtedly of this character and connected with others not so evidently volcanic by transitional materials, the whole associated with some rocks which must have approached ordinary argillites in composition and with quartzites.[1] If correct in this instance, as I believe them to be, similar conclusions will apply to a great portion of the rocks of other localities supposed to be of Huronian age, as a perusal of their description in the "Geology of Canada" will render evident. In the felspathic and gabbro-like rocks of the Upper Laurentian, we have a series so completely the same in composition with certain abundant modern volcanic rocks, that the attempt to account for its composition by pseudomorphism, or by the theory of chemical precipitates unlike

[1] Geology and Resources, 49th Parallel, 1875, p. 52.

those of the present day, seems almost as unnecessary as it would be to invoke a similar remote origin for the formation of an ordinary sandstone. In suggesting volcanic agency as an important factor in the history of the Lower Laurentian, more hesitation may be felt, as the mere area covered by its rocks is so much greater than we would expect to result from any system or linear series of volcanos as at present known. It is still a fact that the greater part of the rocks of that formation are just such as would be produced from the complete metamorphism of volcanic products among which those of the acidic class preponderated. Its limestones and iron ores do not oppose the theory, as these, with the quartzites and graphites may have been formed during periods of repose; and it is also apparent that if considerable areas of recently ejected volcanic matter were from time to time exposed to sub-aerial influences, their decay would furnish lime and iron readily and in great abundance to the surrounding waters, there to be fixed by organic or other agency.

Judging from lithological characters alone, and without presuming to enter into questions of age, it would appear probable, or almost certain, that volcanic sediments or other more or less immediate volcanic products have assisted materially in the production of the crystalline rocks of the Green and White Mountains, and their probable southward continuations; the rocks of the Metamorphic Quebec group, and those of the supposed Huronian of Eastern Massachusetts and Maine. The concise description of these last given in Dr. Hunt's "Chemical and Geological Essays,"[1] might be applied with scarcely a word of alteration to portions of the Mesozoic volcanic series of British Columbia.

If we may be allowed thus to explain the building up of a great thickness of the older rocks by volcanic action, we may economize greatly in the call for geological time, which at present seems desirable. The crystalline character of any series of rocks may reasonably be supposed to depend more closely on their original composition than on subsequent alteration, and in volcanic products —which may be as finely stratified as any—we have the materials of many of the rocks of the older crystalline formations. If, however, the action of volcanos in supplying materials for rock-building on a large scale be admitted as possible at any era in geological time —and there is surely no reason why it should not be admitted—the correlation of separated areas of crystalline rocks on lithological characters alone, from the difficulty of completely eliminating volcanic action, and the precise similarity of the volcanic rocks of all periods, when they have sustained an equal degree of alteration, becomes at least extremely hazardous. On the other hand, as already tated, these rocks, due to the same period, may be found at a similar tage of metamorphism and showing precisely similar characters for great distances in certain lines of volcanic activity and disturbance, and may also be accompanied by parallel belts of contemporaneous materials of ordinary aqueous origin.

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[1] p. 187, § 5.

VIII.—PALÆONTOLOGICAL NOTES.

By R. ETHERIDGE, Junior, F.G.S., etc.

THE following brief notes on rare, little known, or occasionally new fossils, in some cases anticipating more detailed descriptions, may be of interest to the readers of the GEOLOGICAL MAGAZINE.

1. SPIRORBIS AMBIGUUS, Fleming (Edinb. New Phil. Journ., 1825, vol. xii. p. 246, t. 9, f. 3).—This little Annelide appears to have been a good deal lost sight of by palæontologists, and for that reason it may perhaps be well to call attention to it. *S. ambiguus* was not mentioned by Prof. Morris in his "Catalogue of British Fossils," nor by Messrs. Armstrong and Young in their "Catalogue of the Carboniferous Fossils of the West of Scotland." It was originally described by the Rev. Dr. Fleming, in his paper on the British Testaceous Annelides, and placed in the second division of his arrangement of the species of the genus *Spirorbis*, those with the tube "destitute of longitudinal ridges." He obtained it from Cult's Limeworks, near Pitlessie, Fife, adhering to the surface of *Myalina crassa*, Flem. The tube expands towards the aperture, which is round; the umbilicus is open, and the surface unornamented, or very finely wrinkled across. Unlike *Sp. carbonarius*, Murchison, it does not, so far as I have observed, make a groove for itself in the surface of the body to which it is attached. In general appearance *Sp. ambiguus* closely resembles *Spiroglyphus marginatus*, M'Coy. It will be a question for careful consideration whether this species, from its early enunciation, will not absorb some of the later described forms; amongst the latter I would recommend particular attention being paid to *S. minuta*, Portlock, and *S. omphalodes*, Goldfuss. Mr. Bennie has obtained *S. ambiguus* from Roscobie Quarry, Fife, in addition to the typical locality.

3. In a bed of shale above a limestone of the L. Carb. Limestone group at Hillhead Quarry near Cockmuir Bridge, and Whitfield Quarry near Carlops, occur peculiar little microscopic onion-shaped bodies in thousands. They very much resemble an onion in general appearance, but at the same time are indistinctly four-lobed and provided with a small peduncle or stalk. The form is usually round or globular, and the four-lobed character is caused by furrows or constrictions, but always in a symmetrical manner. Occasionally, they are met with of a more flattened form, but still showing traces of the four-lobate structure. I forwarded these little bodies many months ago to Mr. H. B. Brady, who informed me that he was well acquainted with them, that they bore no Foraminiferal characters, and usually occurred in large numbers together, but seldom where Foraminifera abounded. He adds, "I suspect they must be vegetable. They occur in one of the beds of the Yoredale Rocks (England), where they are very abundant." I have not been able to detect any structure which would lead me to assign to them any particular position in the Animal Kingdom. If they are not Foraminiferal, and of this there can be no better judge than Mr. Brady, and so far as I have seen there does not appear to be any Echinodermal structure about them, we are reduced to the alternative of regarding them as of vegetable origin. May they be Sporangia?

Collector, Mr. James Bennie.

4. BORINGS IN THE SHELL OF CHONETES LAGUESSIANA, de Kon.—Specimens of this species from shale above the limestone at Roscobie Quarry near Dunfermline are perfectly riddled with fine borings quite perceptible to the naked eye. They appear to be of two kinds. Those seen on the exterior of the ventral valve are straight, and all more or less tending in one direction, generally parallel with the surface striæ of the shell, but at times crossing these latter at an angle. The second kind are visible on the dorsal valve, they are irregularly festoon-shaped, and are more commonly confined to near the front margin of the valve, but all connected with, and running into one another. Each boring appears to form almost a semicircle; these being placed in longitudinal rows, and connected by their extremities with the row in front, give rise to the appearance of irregular festoons. They may be the borings of sponges, or perhaps of parasitic algæ (?).

Collector, Mr. James Bennie.

5. Some very minute, quite microscopic, flask or bottle-shaped little bodies were obtained by Mr. Bennie from the shale above the the limestone at Roscobie Quarry, Fife (L. Carb. Limestone Group). They may be described as elongately bottle-shaped, inferiorly tapering almost to a point, expanding at about the centre, becoming constricted towards the superior end, where bifurcation takes place. The larger portion, which is the cell-mouth, is bent almost at right angles to the imaginary axis of the fossil; the other portion is continued vertically as a small connecting stolon for the cell which would succeed. They have a shining hyaline appearance. Examples were forwarded to the Rev. T. Hincks, who was kind *enough to confirm* my previously entertained suspicion as

to their Polyzoal affinities. He remarks that the little bodies appear to come very near the recent genus *Scruparia*, and its ally *Hippothoa*. He adds, there is also a Cretaceous species of the genus *Æa* (*Æ. anguinaria*) closely related to them. The present form need not be mistaken for either of the following Palæozoic species:—*Hippothoa Voigtiana*, King, Permian Foss. England, 1850, p. 31, t. 3, f. 13; Gienitz, Dyas, p. 120, t. 20, f. 24, 25; *H. inflata*, Hall, Nicholson, Ann. Nat. Hist., 1875, vol. xv. p. 123, t. 11, f. 1. As regards size, *H. inflata*, Hall, approaches nearest to our Carboniferous forms, but it is much larger. I propose to call this *Hippothoa*? *Hincksii*, and hope before long to give a more detailed description and figure.

(*To be continued.*)

NOTICES OF MEMOIRS.

I.—The Forest-bed of East Norfolk. By Henry Norton, F.G.S. Paper read before the Norwich Geological Society, May 1st, 1877.—*Norwich Mercury*, May 5th.

THE author first refers to an excursion made to Mundesley and Happisburgh by members of the Norwich Geological Society, an account of which was published in the *Eastern Daily Press*, of February 15th. It was therein stated that "several stools of trees, with roots branching out, were seen, and proved on examination to have grown upon the bright blue clay of the soil of the forest." Having been unable to attend the excursion, he went two days later for the special purpose of ascertaining whether the stumps of trees observed were actually *in sitû* as they grew. The few he was enabled to examine, although they had a false appearance of having grown where found, had their roots broken off, and could not have lived on the spots. They might very naturally have been drifted into such positions.

The poor result of his visit induced him to examine what is the evidence on which the belief in the Forest-bed rests; and the main object of the present paper was to point out how unsatisfactory were the statements of those who have written upon the subject. He referred to the observations of R. C. Taylor, Rev. J. Layton, S. Woodward, J. Trimmer, and to those of Mr. Prestwich and Mr. John Gunn. Lyell had never seen the stools of trees *in sitû*. The statements made by these geologists were all vaguely general. No one had taken a particular stump, examined the condition of the roots, whether whole or broken, and told us their actual length and their position on the ground. It was known that remains of oak have been found, but we were never told that any particular stool was oak; nor have we ever been told that any particular trunk was ever found lying near its own stool. It was, in fact, only too clear that our observers in general did not appreciate the value of precise facts as opposed to loose generalities.

Mr. Norton was ready to admit the high, very high probability, of a forest *in sitû*, but contended that there was yet no absolute proof of it. H.B.W.

II.—NOTES ON FOSSIL PLANTS.

[Communicated by Count MARSCHALL, C.M.G.S., etc.]

1. *Sandstones of Gröden, between Neumarkt and Mazzon, South Tyrol.*

(Imp. Geol. Instit. Vienna, Meeting January 9, 1877.)

THE strata here are horizontal in a hill, at the summit of which is Mazzon. Beginning with the lowest beds (near Neumarkt, at the foot of the hill), Nos. 1, 3, and 5 are grey and red sandy and argillaceous beds of the "Gröden Sandstone"; 2. White sandstones, with vegetable remains; 4. Subordinate beds of grey shales, with vegetable remains; 6. Yellow dolomitic strata, partly oolitic and glauconitic, and white compact limestones, interspersed with malachite; 7. "Seisser beds," on which Mazzon is situate.

The plant-remains in No. 2 are indeterminable stems and trunks, with carbonized bark, well preserved and large *stobili* (of *Voltzia Hungarica*?), branches with acicular leaves, fronds of Ferns, and here and there some few Calamites. The very friable bed No. 4 includes perfectly preserved bracts, acicular leaves, short branches, and *strobili.*

Altogether the *facies* of this Flora is Triassic, like that of the "Roth" Flora of Zweibrücken. On closer investigation, however, these Floræ do not possess one species in common. Professor Schimper thinks the Flora under notice to be probably of Permian age. Almost all the species are identical with those of Fünfkirchen in Hungary, which, according to Prof. Heer, are of Post-carboniferous or Upper Dyasic age. The branches and strobili of *Voltzia Hungarica* prevail in number; with them occur *Baiera digitata*, Heer, *Ullmannia Bronni*, Heer, *Ullm. Geinitzi*, *Carpolithes*, fronds of Ferns, *Calamites* (or *Equisetites*), *Lingula* sp., some few Fish-scales, etc.

More or less frequent and distinct fragments of *Voltzia Hungarica* have been found at several places in the Tyrol, a fact worthy of notice, as, at these localities, the typical black Bellerophon-limestones (represented near Neumarkt by yellow dolomitic rocks) rest immediately on the strata containing plant-remains. The most frequent Foraminifera in the Bellerophon-limestones are *Cornuspirida*, especially a form near *Endothyra.*

2. *On some Rhætian Plants from Pälsjö, South Sweden.*—By Dr. NATHORST.

(Imp. Geol. Instit. Vienna, Meeting January 23, 1877.)

Dr. R. H. Nathorst lately presented to the Imperial Geological Institute of Vienna a collection of fossil plants from Pälsjö. The species represented in it are—*Spiropteris*, sp., *Rhizomopteris Schenki*, Nath., *Cladophlebis Nebbensis*, Brong., *Gutlieria angustiloba*, Presl, *Dictyophyllum Muensteri* (Gopp.), Nath., *Nilssoni*. Brong., *Nilssonia polymorpha*, Schk., *Anomozamites gracilis*, Nath., *Podozamites distans*, Presl, *Palissya Brauni*, Endl., *Schizolepis Follini*, Nath., *Pinites Lundgreni*, Nath. (a well-preserved Strobilus), and *Swedenborgia cryptomerides*, Nath. In a letter to Prof. D. Stur, Dr. Nathorst observes concerning these remains:—*Rhizomopteris Schenki* is undoubtedly no rhizome of a *Dictyophyllum*. Denticulation is visible on a fragment of *Cladophlebis Nebbensis*, as in an Austrian specimen of *Cladophlebis*. The leaves of *Gutlieria* are constantly found with fructification. *Sagenopteris*. *Otenopteris*, and *Thimfeldia* are very rare. The occurrence of genuine *Dictyophyllum Muensteri* and *D. Nilssoni* may be doubted, the Pälsjö specimens of this last species having less regular and shorter secondary segments, although not so short and broad as those of *D. acutilobum*, Schenk, but perfectly concordant with the Transsylvanian *Campt. Nilssoni*. Perhaps the Pälsjö species shows transitions to *Dictyophyllum rugosum*, and *D. Leckenbyi* may be admitted as a distinct species under the name of *D. polymorphum*.

The nerves of *Nilssonia polymorpha* are invariably simple, and the lamina covers completely the upper side of the rhachis. In all the *Pterophylla*, from the Trias up to the Cretaceous, the segments are laterally attached to the rhachis, not covering it completely, and a certain number of nerves at the base are dichotomous; good distinctive generic characters. There are, however, transitional forms, such as *Pterozamites Blasii*, Braun. *Cycadites longifolius*, somewhat reminding us of the Chinese *Taxites spathulatus*, Newb., may possibly be a Conifer. The least frequent variety of *Podozamites distans* is the typical form, *genuina*. *Podozamites ovalis*, Nath., may be a variety of *Podoz. distans*. The Strobili of *Schizolepis* are generally so much worn by rolling that the division of the scales is indistinguishable.

3. *Fossil Plants from Eastern Siberia.*—By Dr. St. T. SCHMALHAUSEN.

(Imp. Geol. Inst. Vienna, Meeting of January 23, 1877.)

In 1873, Mr. Lopatin, a Russian Mining Engineer, discovered among the pebbles of the River Ogux (an affluent of the Yenisei), impressions and casts of plants in fragments of sandstone. The species, as far as they can be ascertained, are:

Bornia radiata (Brong.).
Filicites Ogurensis, Schmalh.
Lepidodendron Veltheimianum, St.
Bergeria regularis, Schmalh.
,, *alternans*, Schmalh.
Lepidodendron Wiikianum, O. Heer.
Lepidostrobus gracilis, Schmalh.
Knorria, sp.
Cyclostigma Kiltorkense, Haught.
Stigmaria ficoides, St.

The presence of *Cyclostigma Kiltorkense* proves these remains to have belonged to the Lower Carboniferous.

4. *On the Permian Plants of Fünfkirchen, Hungary.*—By Prof. O. HEER.

(Imp. Geol. Inst. Vienna, Meeting of January 23, 1877.)

The species found in this locality are:

Baiera digitata (Brong.)
Ulmannia Geinitzii, Heer.
Voltzia Hungarica, Heer.
,, *Boeckiana*, Heer.
Schizolepis permiensis, Heer.
Carpolithes Klockeanus (Gein.).
Carpolithes Hunnicus, Heer.
,, *foveolatus*, Heer.
,, *Eiselianus* (Gein.).
,, *libocedroides*, Heer.
,, *Geinitzii*, Heer.

They occur in shales, intercalated between brownish, yellowish-grey, and occasionally red sandstones, beneath coarse Triassic quartz-conglomerates, at the base of the variegated sandstones with *Myophoria costata*, being a part of the lower horizon of the Fünfkirchen shelly limestones. Nearly one-half of these species are found in the Copper-shales of the Saxon and Franconian "Zechstein." *Ullmannia Geinitzi* and its congener *U. Brauni* are characteristic Dyasic (Permian) forms. The specimens of *Voltzia Hungarica*, Hr., are identical with *Palissya Brauni* in the form and the distichous arrangement of their leaves, and in the form of their branches, and would find a better place in this genus; the forms generally ranked among *Voltzia* having no median nerve, and the arrangement of their leaves being polystichous. The scales of strobili, possibly not connected with the branches found here, stand very near those of *Voltzia*.

5. *On the Upper Tertiary Plants of Sicily.*—By Dr. H. Th. Geyler.

(Imp. Geol. Instit. Vienna, Meeting of March 6, 1877.)

These plants, together with fossil Insects, have only been found in the lacustrine gypsum and sulphur-bearing beds of the hill range of Cannatone, north of Racalmuto and Grotte, in the Province of Girgenti. The species, denoting an earliest Pliocene origin, represent the genera *Xylomites*, *Furcellaria*, *Algacites* (?), *Pinus*, *Phragmites*, *Poacites*, *Potamogeton*, *Palmacites*, *Myrica*, *Alnus*, *Quercus*, *Cinnamomum*, *Laurus* (?), *Diospyros* (?), *Celamstrus* (?), *Berchemia*, *Juglans*, *Cæsalpinia* (?), *Robinia* (?), and *Acacia* (?). Several of them are identical with those from the Tertiaries of Œningen.

6. *On the Arctic Fossil Plants.* By D. Stur.

(Imp. Geol. Instit. Vienna, Meeting of March 6th, 1877.)

Professor Oswald Heer has lately published the fourth volume of his classic "Flora fossilis arctica," in which he treats of the following localities:—

A. Robert Valley, Research Bay, 77° 33′ N. Lat., explored by Prof. Nordenskiöld. The species collected there are—*Sphenopteris frigida* (compare *Sph. bifida*, Lindl.), *Sph. geniculata*, Germ. (*Sph. sub-geniculata* Stur (from the "Culm"), *flexibilis*, Heer, *Sph. distans*, Stb. (an exclusively "Culmian" form), *Adiantites concinnus*, Goepp. (*Ad. tenuifolius*, Goepp., from the "Culm"), *Ad. bellidulus*, Heer (compare *Ad. oblongifolius*, Goepp., "Culm"), *Staphylopteris*, sp. (Indusia only found in the "Culm"), *Lycopodites filiformis*, Heer, *Lepidodendron Sternbergi*, Brong. (*Lep. Veltheimianum*, St., Gein.), *Lep. selaginoides*, St., *Lepidophyllum caricinum*, Heer, *Stigmaria Lindleyana*, Heer (*Stigm. inæqualis*, Goepp.), *Sphenophyllum longifolium* (?), Germ., *Sphenoph, bifidum*, Heer, *Sphenoph. subtile* (compare *Sphenoph. tenerrimum*, Ett. sp., "Culm"), *Rhynchogonium crassirostre* Heer, *Rh. costatum*, Heer, *Rh. macilentum*, Heer, *Rh. globosum*, Heer, *Cordaïtes palmæformis* (Goepp.), *Cord. borassifolius* (St.), *C. principalis* (Germ.), *Walchia linearifolia*, Goepp. (compare *W. antecedens*, Stur), *Samaropsis Spitzbergensis*, Heer, and *Carpolithes nitidulus*, Heer. According to Professor Heer, this Flora is Middle Carboniferous; the *Calamites*, *Annulariæ*, *Asterophyllites*, *Neuropteridæ* and *Pecopteridæ*, wanting in the above list of species, may have been overlooked by the collector.

Mr. Stur remarks that many of the above-named plants belong to the "Culm" series, or have, at least, very nearly related representatives in this horizon. The genuine *Sphenopteris distans* is a characteristic form of the "Culm."

B. Cape Boheman. The sandstone and carbonaceous beds of this locality, formerly thought to be Tertiary, have proved to be Jurassic ("Brown Jura"; "Bathonian" of the French geologists). Ten of the thirty-two species composing this flora are known to exist in other Jurassic localities. The most remarkable forms are *Podozamites lanceolatus* (Lindley), and *Ginko digitata* (Brong.).

C. Cape Staratchin. A total of 19 species of Cretaceous forms.

D. Cape Lyell, Scott Glacier, and Cape Heer, explored by Prof. Nordenskiöld. All these localities together yield 71 species of Miocene plants. The specimens from Cape Lyell are beautifully preserved, those of the two other localities are not in nearly so good a state.

E. East Siberia and Amoor Province, explored by MM. Schmidt and Glehn. The fossil plants of these regions are of the highest interest for the study of the Jurassic Flora. The species are:—

From *East Siberia, Government Irkutsk:*

Thyrsopteris Murrayana (Brong.)
——— *Maakiana*, Hr.
Dicksonia clavipes, Hr.
Asplenium (*Diplazium*) *Whitbiense* (Brong.)
——— ——— ———, var. *tenuis*, Hr.
Lycopodites tenerrimus, Hr.
Phyllotheca Sibirica, Hr.
Phœnicopsis angustifolia, Hr.
Baiera longifolia (Brong.)

Baiera Czekanowskiana, Hr.
Ginko Schmidtiana, Hr.
——— *Sibirica*, Hr.
——— *lepida*, Hr.
Czekanowskia setacea, Hr.
——— *rigida*, Hr.
Leptostrobus laxiflora, Hr.
Samaropsis rotundata, Hr.
——— *caudata*, Hr.
——— *parvula*, Hr.
Kaidacarpum Sibiricum, Hr.

Amoor Province:

Anomozamites Schmidtii, Hr.
Podozamites Eichwaldi, Sch.
Phœnicopsis speciosa, Hr.
Czekanowskia setacea, Hr.

Thyrsopteris prisca, Eichw.
Dicksonia Saportana, Hr.
——— *acutiloba*, Hr.
Asplenium spectabile, Hr.

These Floræ, like the scanty one of the Islet of Andoë on the West coast of Norway (only eight species), are characteristic of the Middle Brown Jura (Bathonian).

III.—The Distribution of Cephalopoda in the Upper Cretaceous Series of North Germany. By Herr C. Schlüter.

(Imp. Geol. Instit. Vienna, Meeting January 23, 1877.)

A. Lower Pläner (Cenomanian, d'Orb.).

1. Zone of *Pecten asper*, and *Catopygus carinatus*.
2. Zone of *Ammonites varians* and *Hemipneustes Guepenkerli*.
3. Zone of *Ammonites Rhotomagensis* and *Holaster subglobosus*.

B. Upper Pläner (Turonian, d'Orb.).

1. Zone of *Actinoceras plenum*.
2. Zone of *Ammon. nodosoides* and *Inoceramus labiatus*.
3. Zone of *Ammon. Woolgari* and *Inoc. Brongniarti*.
4. Zone of *Heteroceras Reussianum* and *Spondylus spinosus*.
5. Zone of *Inoceramus Cuvieri* and *Epiaster brevis*.

C. Embser (analogous to the Alpine "Gosau").

Zone of *Ammonites Margæ* and *Inoc. digitatus.*

D. Lower Senonian.

1. Sandy Marls of Recklinghausen, with *Marsupites ornatus.*
2. Quartzose beds of Haltern, with *Pecten muricatus.*
3. Calcareous sandy beds of Dülmen, with *Scaphites binodosus.*

E. Upper Senonian (Cœloptychian Chalk).

1. Zone of *Becksia Sœkelandi.*
2. Zone of *Ammonites Cœsfeldensis.*
3. Zone of *Ammon. Wittekindi* and *Heroceras polyplocum.*

COUNT M.

IV.—THE FOOD OF A SIBERIAN RHINOCEROS.

(Imp. Geol. Instit. Vienna, January 23, 1877.)

Dr. St. J. Schmalhausen has microscopically examined the remnants of food contained in the cavities of the teeth of a North-Siberian Rhinoceros (*Rh. antiquitatis*) whose remains are preserved in the museum of Irkutsk. These are remnants mostly of leaves, and of some stems, chiefly monocotyledonous. There are fragments of grasses, and of small twigs of some woody plants, such as *Picea* (*obovata*?), *Abies* (*Siberica*?), *Larix* (*Siberica*?), *Ephedra*, sp., *Salix*, sp. (prevalent), and *Betula* (*fructicosa*?). All these plants still exist in high northern latitudes, and confirm Brandt's supposition, that the Pachyderms of North Siberia lived in the regions where their remains, partly preserved by frost, are now found.—COUNT M.

V.—THE SPECIES OF MASTODON IN EUROPE.

Herr M. Vacek stated at the meeting of the Imp. Geol. Instit. Vienna, February 6, 1877, that of the seven species of Mastodon known to exist in the European Tertiaries, five have been ascertained to have lived within the region of the Austro-Hungarian empire. These are *Mast. Borsoni*, *Mast. tapiroïdes*, *Mast. angustidens*, *Mast. longirostris*, and *Mast. Arvernensis.*

VI.—ON AN OSSIFEROUS CAVE IN THURINGIA. By DR. K. TH. LIEBE.

(Imp. Geol. Instit. Vienna, February 20, 1877.)

A small Bone Cave was discovered late in the autumn of 1874, in the Linden Valley, South of Gera in East Thuringia. The animals whose remains are found in this cave (probably a Hyæna-den, of rare occurrence in Germany), arranged according to their relative frequency, are, *Equus fossilis*, *Hyæna spelæa* (nearly all the bones broken and evidently gnawn), *Rhinoceros tichorhinus*, *Bos primigenius*, *Ursus spelæus*, *Felis spelæa*, *Cervus elaphus*, *Cerv. alces*, *Cerv. tarandus*, *Elephas primigenius*, *Alakdaga geranus*, *Vulpes vulgaris*, *Canis*, sp., *Arctomys marmotta*, *Arvicola gregalis*, *Mus rattus*, *Cervus capreolus*, *Mustela*, sp., *Lepus*, sp., *Tetrao tetrix*, *Pandion haliaëtus*, and *Charadrius*, sp. The presence of *Alakdaga* (a species of Gerboa), now living in the Steppes of extreme East Europe, and of *Arvicola gregalis*, an inhabitant of high Northern latitudes in Europe and Asia, are specially worthy of notice. The remains of these two species have also been found by Dr. Wehring near Westeregelt, associated with those of Rhinoceros, Horse, Marmot, Lemming, etc.

Split bones, worked fragments of horns, and flint implements were also found in this cave. The dolomitic detritus, heaped in form of a terrace before the cave, is full of bone splinters and broken antlers of Reindeer, without any traces of having been gnawed by Hyænas.—COUNT M.

REVIEWS.

I.—THE FORAMINIFERA OF THE PLIOCENE BEDS OF BELGIUM. By E. VANDEN BROECK and H. MILLER. Part I. GEOLOGICAL AND PALÆONTOLOGICAL SKETCH OF THE PLIOCENE DEPOSITS OF THE NEIGHBOURHOOD OF ANTWERP. By E. VANDEN BROECK. Fasc. i. THE LOWER ANTWERP SANDS. pp. 101. 8vo. (Brussels.)

THIS important contribution to Belgian geology is endorsed "Extracted from the Annals of the Malacological Society of Belgium, vol. ix. 1874," but was published separately late in 1876. It forms the first instalment of a series of publications in course of preparation, constituting a monograph of the Belgian Pliocene Foraminifera. The second instalment is on the eve of publication.

The chief points to which the author draws attention in the portion before us are:—1st. The conditions under which the Pliocene deposits of W. Europe were formed; and 2nd. The alterations which those deposits have subsequently undergone.

The Miocene Period is unrepresented in the Anglo-Belgian area by any deposit; the subsidence of that area initiating the Pliocene Epoch. The gulf thus formed was partly occupied by mollusca, etc., migrating from the Vienna Miocene Basin (then beginning to shallow) through Silesia and N.W. Germany.

The earliest deposit is characterized by *Panopœa Menardi*; it is a slightly clayey sand, of a dark olive-green colour from the abundance of glauconite grains. The fauna denotes water of 100 to 200 feet in depth, about two-thirds being Gasteropods. Partly synchronous with the later beds of this zone are sands characterized by *Pectunculus pilosus*, equally glauconitic but less clayey, and with a littoral fauna, two-thirds of which are Lamellibranchs. Of slightly later date are the Gravelly Sands of Diest and Antwerp, completing the Lower Sands of Antwerp, which have no British equivalent except the traces of questionable age on the Kentish Downs. The synonymy of this part of the series is treated at considerable length by the author, resulting in the following condensed statement:—

LOWER ANTWERP SANDS.

Diestian System: Dumont, 1839; Dujardin, 1862; Dewalque, 1868.
Lower or Black Crag: Lyell, 1852; Dewael, 1853.
Diestian Sands: Dewalque, 1868; Mourlon, 1873; Cogels, 1874.
Black Antwerp and Edeghem Sands: Omalius d'Halloy, 1862.

The synonymy of the sub-divisions is as follows:

Panopæa Menardi SANDS: (Black) Edeghem Sands.

Pectunculus pilosus SANDS: Shelly glauconitic Sands, Dumont and Dewael; Black Sands of Fort Herenthals, Nyst, 1843; Black or Lower Antwerp Crag, Lyell and Dewael; Black Antwerp Sands, Omalius d'Halloy, Dujardin, and Mourlon.

GRAVELLY SANDS OF ANTWERP AND DIEST.

Green Sand, Dujardin, Mourlon, and Cogels; Diestian System, Glauconitic Diestian Sand, Ferruginous Sand and Grit, Dumont; Diest Sands, Omalius d'Halloy, d'Archiac, Lyell, Dewalque, and Mourlon.

Throughout the formation of this series subsidence was going on to the N.W. and emergence to the S.E., so that each zone overlaps the N.W. edge of its predecessor, but does not reach its S.E. border.

The Middle and Upper Antwerp Sands (corresponding to the English Coralline and Red Crags respectively) follow, and will be described in a future memoir.

As against the placing of the Lower Sands in the Miocene or terming them Diestian, it is urged that the break between the Oligocene or L. Miocene and the Lower Sands is greater than any break in the whole Antwerp Series, and the principal break in the latter is between the Middle and Upper divisions, both admittedly Pliocene (Scaldisian).[1]

Lists of fossils of the Lower Sands are given, relative abundance, range, etc., being shown. With a caution as to the effect of bathymetric differences and the incompleteness of our knowledge of the existing fauna, the relative numbers of extinct and recent species are stated to be as follows: *Panopæa Menardi* zone 44 per cent. recent; *Pectunculus pilosus* zone 51 per cent. recent, or on the average 47 per cent. for the whole. 47 per cent. occur in the English Coralline Crag, and 51 per cent. in the English Crags generally.

The Lower Sands range from N. France into Holland and N.W. Germany, but there is no evidence that they ever extended into England, as the pebbles of rock of that age in the Basement Beds of the Coralline and Red Crags may have been derived from the Belgian area. Traces of the Gravelly Sands occur on the Kentish Downs (these are regarded by Mr. Whitaker as probably Eocene, see *Mem. London Basin*, p. 336).

Errors have arisen from the alteration of the glauconite in these beds, and from the removal of the shells by percolating waters, an important discovery made independently by English and Belgian observers in 1876. The shells are first rendered friable and then completely removed by carbonated waters (occasionally leaving impressions and casts), whilst the glauconite is decomposed first into pale-green protoxide, and finally into deep red-brown peroxide of iron.[1] The altered portions are sometimes separated by a sharp line from, at other times graduate imperceptibly into, the unaltered. The unfossiliferous ferruginous or pale-green part of such beds has not seldom been separated from the unaltered part as a posterior formation, whilst the irregularity of the line of junction (due to varying porosity or to the presence of protecting beds of clay), has been described as proof of unconformity between the two series. W.H.D.

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[1] A trivial objection is made to the use of the term Black Crag, that the deposit is unrepresented in England, and is therefore not Crag. But by use and wont "Crag" is all but synonymous with Pliocene, and similar exception might be taken in every case where a foreign series bears the name of its less-developed British equivalent.

II.—A TEXT-BOOK OF MINERALOGY, WITH AN EXTENDED TREATISE ON CRYSTALLOGRAPHY AND PHYSICAL MINERALOGY. By EDWARD S. DANA. On the Plan and with the Co-operation of Prof. JAMES D. DANA. With upwards of 800 Woodcuts and one Coloured Plate. 8vo. pp. 485. (New York, John Wiley & Sons; London, Trübner & Co., 1877).

AMONG the various writers who have contributed systematic works, text-books and guides, to the science of Mineralogy, no author so richly deserves the thanks of English students of this branch of study as Professor James D. Dana, of Yale College, Newhaven, Ct., U.S.A., the father of Mr. Edward S. Dana, the editor and part author of the volume before us. When it is borne in mind that the first edition of "A System of Mineralogy," by James D. Dana, appeared as long ago as the year 1837, and that the *fifth* and last edition appeared in 1868, it will, we think, be readily conceded that we owe to Prof. Dana a vast obligation for his valuable services to mineralogical science. Nor have these several editions been, as is too often the case, merely reprints slightly modified and corrected; but in great part they have been re-written and largely increased in extent of contents; so much was this the case that in the 1868 edition it was found necessary to greatly abbreviate the introductory chapters on chemical and determinative mineralogy, the great feature of the fifth edition being the descriptive portion, which still remains unequalled by any work on this subject in the English language. The great demand for Dana's System of Mineralogy led its author to undertake, in 1868, the preparation of a "Text-Book of Mineralogy"; but the state of Prof. Dana's health however early compelled him to relinquish the work. and he was not able subsequently to resume it.

Finally, after the lapse of seven years, the editorship of the volume was placed in the hands of Prof. Dana's son, Mr. Edward Salisbury Dana, who has with great care endeavoured to carry out his father's original plan.

The work has been arranged with a view to meet the requirements of class instruction. With this object in view the descriptive part has been made subordinate to the more important subjects embraced under Physical Mineralogy. Thus the Text-Book now issued forms a companion volume to the fifth edition of the System of Mineralogy published in 1868, rather than as superseding it.

The Crystallography is presented after the methods of Naumann;

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[1] The Red Crag of Suffolk and the yellow flagstones of the Carboniferous Rocks are, in certain cases of protection from oxidation of their contained iron, of a greyish-blue colour.

his system being most easily understood by beginners, and most convenient for giving a general knowledge of the principles of the science.

For use in calculations it is, however, much less satisfactory than the method of Miller, and a concise exposition of Miller's system has therefore been added in Appendix "A."

The chapter on the physical characters of minerals has been expanded to a considerable length, especially as regards their optical properties, but not more so than was absolutely necessary in order to make clearly intelligible the practical application of the principles of optics to the study of crystals.

The descriptive part, which, as already stated, has been made subordinate to that of physical mineralogy, is identical in general arrangement with that of Dana's "System of Mineralogy," to which reference must still be made for fuller descriptions of many uncertain species and varieties with descriptions of localities and methods of occurrence.

A large part of the figures are reproduced from Dana's System of Mineralogy; but 200 are new to this work, and greatly enhance its interest and usefulness to the student.

The chemical formulæ given in the 5th edition of the System of Mineralogy are only in part those of modern chemistry, but those of the present work are uniformly in modern notation.

In addition to Appendix "A," treating of Miller's Crystallography, we have in Appendix "B" a most important chapter on the drawing of figures of crystals, and "C," a series of Tables to be used in the determination of minerals, whilst "D" is a Catalogue of American localities of minerals essentially the same as that contained in the last edition of the "System," but with considerable additions derived from various printed sources and from private communications.

The book is one which reflects great credit on its authors, and cannot fail to prove a most acceptable addition to our series of higher text-books, for which no doubt there will be as great a demand as for the several editions of Dana's System of Mineralogy.

T. D.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—May 23, 1877.—Professor P. Martin Duncan, M.B., F.R.S., President, in the Chair.

The President read a letter from C. J. Lambert, Esq., announcing that his father, the late C. Lambert, Esq., F.G.S., had left by will the sum of £25,000 to be distributed in gratuities to persons in his employ, and in gifts to scientific societies. The distribution of this amount was left to the judgment of Mr. C. J. Lambert, who allotted the sum of £500 to the Geological Society. The President further announced that the sum of £500 had already been paid to the Society, and would be invested for its benefit.

The President also announced that a letter had been received from

Count Gaston de Saporta, F.C.G.S., expressing the hope that Fellows of the Society would attend the meeting of the French Association for the Advancement of Science, which will be held in August next in Havre. Count de Saporta stated that any Fellows attending the Meeting will be exceedingly welcome, and that any who will send word previously of their intention to come will meet with a most cordial reception. In connexion with this it was further announced that, according to a circular from the Geological Society of Normandy, that Society proposes, during the meeting of the Association, to hold a Geological Exposition, intended as preliminary to that to be held in Paris next year, and that it invites co-operation.

The following communications were read;—

1. "Remarks on the Coal-bearing Deposits near Erekli, the ancient Heraclea, Pontus-Bithynia." By Rear-Admiral T. A. B. Spratt, C.B., F.R.S., F.G.S.

In this paper the author described the occurrence of true Coal-measures near Erekli, on the north coast of Asia Minor, from observations made by him when on service in the Black Sea in 1854. The coal was obtained near Kosloo, about 30 miles east of Erekli, where it cropped out on the sides of a valley, and was worked by horizontal drifts. The district was much disturbed by faults, and the workings could only be driven from 100 to 400 yards into the hill. In the eastern ridge bounding the valley of Kosloo there were 11 or 12 seams of coal of different thicknesses in a distance from N. to S. of about 2 miles, one of them being about 18 feet thick, and the best coal forming a seam of 4 ft. 10 in. The seams dipped S.E. about 26°. They were interstratified with shales, sandstones, and conglomerates of quartz-pebbles, and occasionally with thin bands of clay and ironstone. From some of the seams the author obtained fossil remains of plants, which sufficiently prove that these coals belong to the Carboniferous period. They include, according to Mr. Etheridge, species of *Lepidodendron*, *Lepidostrobus*, *Calamites*, *Pecopteris*, *Sphenopteris*, *Neuropteris* (?), *Sigillaria*, *Stigmaria*, *Glossopteris* (?), and *Sphenophyllum*. The author also noticed several other localities in the immediate neighbourhood where coal was known to exist under somewhat similar conditions. He also referred to the geology of Erekli itself, and noticed especially the occurrence of patches of more or less altered shales and marls, probably of middle Tertiary age, overlying the igneous rocks of which the country consists.

2. "On the Structure and Affinities of the Genus *Siphonia*." By W. J. Sollas, Esq., B.A., F.G.S.

This paper contained, first, a full account of the history of the genus *Siphonia*, including a complete list of its described species, and, next, a description of its general and minute structure. Its skeletal network was shown to consist of spicular elements belonging to the Lithistid type of sponges, and most closely allied in generic details to the recent form *Discodermia polydiscus*. Not only in this character but in every other, *Siphonia* was shown to approach *Disco-*[redacted]so closely as to be almost identical with it.

The mineral replacements which have affected the siliceous skeleton of *Siphonia* were then considered: in specimens preserved in phosphate of lime from the Gault of Folkestone the spicules have undergone a replacement by calcic carbonate, while those from the greensand of Haldon and other localities still possess a siliceous composition, though the interior of the spicules has been dissolved away so as to enlarge the axial quadriradiate canal to a surprising extent; and the silica so dissolved has been re-deposited on the exterior of the spicule, so as to fill up the interstices of the network, and in some cases the cavities of the canal system of the sponge. Thus, to some slight extent, these specimens may be said to have fossilized themselves.

Choanites was shown to be the deep-sea form of *Siphonia*, the latter characterizing Greensand deposits, which were laid down in depths corresponding to those in which existing Lithistids now flourish, while the former is characteristic of the chalk which was deposited in a deeper sea.

The paper concluded with a systematic description of the genus.

3. "On the Serpentine and Associated Rocks of the Lizard District." By Rev. T. G. Bonney, M.A., F.G.S., Fellow and late Tutor of St. John's College, Cambridge.

The author stated that considerable doubt appeared still to exist as to the true relations of the Lizard serpentine and the associated hornblende schists; and as to the origin of the serpentine. He had carefully examined all the junctions accessible on the Cornish coast (inland they are generally obscured). Some of them are concealed by débris, etc.; but the majority prove beyond doubt that the serpentine is intrusive. Further, almost everywhere large fragments of hornblende schist are caught up and included in the serpentine.

Besides the serpentine there is a large mass of gabbro at Crousa Down, and many dykes and veins along the east coast almost to the extremity of the serpentine region. At Coverack Cove, near the above mass, are gabbros of two ages, the older much resembling a kind of troktolite. On microscopic examination it proves to be chiefly plagioclase felspar, augitic minerals (including diallage), and olivine partially converted into serpentine. There is a red and a green variety. The newer, a coarser variety, appears to be of the same age as the other veins on the coast, and connected with the main mass. Some remarkable changes have taken place in this also. In certain places it exhibits a separation of its mineral constituents, causing it to resemble a foliated rock. This is proved to be due to pressure at right angles to the structure. The minerals also are often changed. The felspar is replaced by a white granular mineral resembling saussurite; the diallage (which occurs sometimes in very large crystals) is often partially, or even wholly, converted into rather minute crystalline hornblende. In these specimens there is no olivine to be distinguished. The great mass, however, is rich in olivine, yet a weathered specimen from it, resembling in aspect the gabbro of the veins, does not show olivine. Hence the author believes that in certain cases the olivine, instead of being converted into serpentine, aids in forming the hornblende. Further, there are dykes and veins over the same area of a dark trap. Some of these are augitic, others hornblendic. The author believes that at any rate in certain of these the hornblende is of secondary formation. On the west coast are veins of granite; those on the east coast, said to be granite, prove, on careful examination, to be altered rock, remarkably like granite veins, but not really such.

In discussing the origin of the serpentine, the author called attention to a structure commonly seen, which appeared to be a true "fluidal structure." He then described the result of microscopic examination of many specimens of the Lizard and some other serpentines. Commencing with slightly altered Lherzolite (from the Ariége), he traced the change through the older gabbro of Coverack to the serpentine rock of that place, which contains a large quantity of unaltered olivine; and so to other serpentines in which the olivine is quite replaced by the mineral serpentine. He described also the mode of the change. The other minerals found in the serpentine rock are enstatite, varieties of augite, and occasionally a fair quantity of picotite, with, of course, oxides of iron. Hence he concluded that, as had been already shown as regards some other serpentines, that of the Lizard was the result of the hydrous alteration of an olivine rock, such as Lherzolite.

4. "On certain ancient Devitrified Pitchstones and Perlites from the Lower Silurian District of Shropshire." By S. Allport, Esq., F.G.S.

In this paper the author described a series of ancient vitreous and semivitreous lavas, with their associated agglomerates and ashes, constituting the ridge of Ercal Hill, Lawrence Hill, and the Wrekin, and the low ridge parallel to this to the west, both of which are marked as "greenstone" on the Geological Survey Map. Their composition and structure show them to have been originally identical with some of the glassy volcanic rocks ejected during the most recent geological periods. After noticing the geological relations of these rocks, the author described the structure of modern perlitic and spherulitic rocks, and pointed out that the spheroidal balls which characterize them are produced by a process of more or less concentric cracking during the contraction of the mass after it has been solidified. He then indicated the characters of the ancient rocks of the Lower Silurian district of Shropshire, and showed their identity of structure with the modern spherulitic pitchstones and perlites; he also noticed that in some instances they had become devitrified. As the result of his investigation, he says that the structure of these rocks proves their original vitreous condition; for the perlitic and spherulitic formations, with their associated microliths, are only observed in connexion with the obsidian or pitchstone varieties of volcanic glass; and that in the older as in the younger series there is the same gradation between the vitreous and stony varieties.

II.—June 6th, 1877.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Rank and Affinities in the Reptilian Class of the *Mosasauridæ*, Gervais." By Prof. R. Owen, C.B., F.R.S., F.G.S.

The author stated that while the Mosasaurians had been originally referred to the Cetacea by Camper, then to Crocodilia by Faujas de St. Fond, and to the Lacertilia by Cuvier, Prof. Cope had recently thought he recognized in them Ophidian affinities, spoken of them as "sea-serpents," and formed of them an order called Pythonomorpha. He then discussed in detail the various characters presented by the remains of these animals, and arrived at the following conclusions: In the single occipital condyle and the composite structure of the mandible the Mosasaurians are Reptilian, as also in their procœlian vertebræ; in the double occipital hypapophyses, the bifurcate and perforate parietal, the presence of the "columella," the composite formation of the suspensory joint of the tympanic and in the type of the tympanic, the frame of the parial nostrils and the structure and attachment of the teeth, they are Lacertian. In one special dental modification they are Iguanian, in another Monitorial, and their special group characters consist in the more extensive fixation of the pterygoids and ossification of the roof of the mouth, the large proportion of the vertebral column devoid of zygapophyses, the confluence of the hæmal arch with the centrum in certain of the caudal vertebræ, and the natatory character of the fore and hind limbs. These distinctive characters did not appear to the author to be sufficient for ordinal rank, and with P. Gervais he regarded the Mosasauridæ as a family of Lacertilia equivalent to the Iguanodontidæ and Megalosauridæ in the order Dinosauria. The order Lacertilia among Reptiles, being equivalent to the order Carnivora or Feræ among Mammals, the Mosasaurians would be the equivalents of the Seals in the latter.

2. "Note on the Occurrence of the Remains of *Hyænarctos* in the Red Crag of Suffolk." By Prof. Wm. Henry Flower, F.R.S., F.G.S.

The traces of *Hyænarctos* described by the author in this paper consist of a right and a left first upper molar, which were obtained from the Red Crag of Waldringfield, and are so much alike, that but for the former being rather more worn they might have belonged to the same animal. On comparison these teeth were found to show no appreciable difference from the corresponding teeth of the original specimen of *Hyænarctos sivalensis* from the Sewalik Hills, and hence the author did not venture to regard them as representing a species distinct from the Indian one. The author discussed the synonymy of this species, which was first described by Falconer and Cautley, in 1836, under the name of *Ursus sivalensis*. The genus *Agriotherium* was established for it by Wagner in 1837, and the names *Amphiarctos* and *Sivalarctos* were given to the genus by Blainville in 1841; but Falconer and Cautley's name *Hyænarctos*, although certainly of later date, has been generally adopted. Remains of the genus have been found in the Pliocene marine sands of Montpellier (*H. insignis*, Gerv.), and in Miocene beds at Sansans (*H. hemicyon*), and at Alcoy, in Spain. A nearly perfect mandible of *H. sivalensis* has recently been obtained in its original locality by Mr. Theobald.

3. "On the Remains of *Hypsodon*, *Portheus*, and *Ichthyodectes* from British Cretaceous strata, with descriptions of new species." By E. Tulley Newton, Esq., F.G.S., of H.M. Geological Survey.

Hypsodon lewesiensis, as established by Agassiz in the "Poissons Fossiles," it appears, includes two forms which are generically distinct, and the author felt justified in adopting Prof. Cope's suggestion for their separation. It is proposed to retain the above name for the specimen upon which the genus and species was really founded, and to refer to the genus *Portheus* (Cope), the upper jaw, with large irregular teeth, which had already been described by Dr. Mantell in 1822 as "an unknown fish." To this the specific name of *P. Mantellii* is to be given. Another maxillary bone from the Lower Chalk, characterized by its greater proportionate depth, and the convexity of its dentary border, as well as by the more equal size of its teeth, it is proposed to name *P. Daviesii*.

A very fine specimen from the Gault belonging to this same genus was described in detail. This fish is closely allied to *P. lestris* (Cope), but differs in the form of its maxilla and premaxilla, and is chiefly remarkable for the peculiar incurving of the points of the mandibular teeth. The parts of this specimen which are preserved are—both upper and lower jaws, parts of the palato-quadrate arch, of the hyoid bones, ethmoidal region, brain case, etc. *Portheus gaultinus* is the name suggested for this species.

Hypsodon minor (Egerton), figured in Dixon's "Fossils of Sussex," will now, it is thought, on account of the regularity of its teeth, have to be placed in the genus *Ichthyodectes* (Cope).

Another small mandible from the Lower Chalk of Dorking, which is distinguished by the regularity of its slender, incurved, and

·m one horizon; the slate breccias of Blores Hill, Bradgate, verscroft Mill, Markfield, Bardon, and High Towers, a second; ɜ coarse ash-beds of Benscliff, Chitterman Hill, Timberwood Hill, d the Monastery, a third; and the quartzose rocks of Charley ood, Charley, the Old Reservoir, and Blackbrook, a fourth.

Hence they showed that the beds are considerably dislocated near ɜ Syenites, which removes the main objection which previous :iters have urged against these being intrusive; and they described ɜ evidence they have obtained as to this being their real nature. ɪis evidence included the description of actual contacts of igneous d sedimentary rock seen at two points in the wood south of ·adgate House, and at a third in Bradgate Park.

They propose, in a continuation of the paper, to touch upon the .ults, and to describe in greater detail the microscopic structure of ɜ rocks.

CORRESPONDENCE.

THE NORFOLK FOREST BED.

SIR.—At your request, I gladly furnish you with all the informa- n I can respecting the stools of trees being found, *in situ*, where ·y grew in the Forest-bed on the eastern coast. I have repeatedly ·n them at Happisburgh, and once in the company of Professor :lgwick and of Professor Harry Seeley, who, at a meeting of the ological Society in 1876, gave a vivid description of the appear- ;e of the stools of trees, and of the gratification which Professor lgwick expressed on seeing them.

l have also seen them, *in situ*, at Bacton, on a recent excursion of 'eral of the members of the Norwich Geological Society, by whom ; stool in particular, which grew out of the blue clay of the soil the forest, was examined, and ascertained to be rooted in its ive soil.

)n the excursion to Cromer of the members of the British Asso- ion in 1868, the company assembled on the beach at Overstrand, he spot where the stool of a tree stood on the soil of the forest. ıg invited, I endeavoured to explain that the trees grew on the arine soil, in which the bones of the *Elephas meridionalis* were ciated with Cetacean remains, after it was raised above the ace; and that then the growth of the forest commenced, of which *Elephas antiquus* was the typical mammal. This stool was dug ·y the direction of Lady Buxton, who placed it, where it now is, he Norwich Museum. Mr. Reeve, the Curator, says that one of roots was about four feet long, and he was obliged to have it tened to get it into its case.

ıe above mentioned are the principal places where remnants of Forest-bed have survived its general destruction and denudation Kessingland in Suffolk to Runton in Norfolk beyond Cromer. trees were torn up, and together with fossil remains were re- ·sited in the laminated beds above; and hence it is, no doubt, so few of the trees, or rather of the roots and stumps, are to be at present *in situ*, in proportion to the débris. The evidence, however, of the late Samuel Woodward, who may truly be said to be the Father of Geology in the eastern counties, and whose memory I honour as my preceptor; of Sir C. Lyell and Mr. Symonds, late of Cromer; of R. Taylor, author of "The Geology of East Norfolk;" and of the Rev. Charles Green, author of "The Geology of Bacton" (page 69), is so direct that it would be a waste of time to add more. As a question has been raised by Mr. Norton as to the validity of the evidence of Sir C. Lyell, and also of Mr. Symonds, I will mention an incident which occurred at Cromer in 1862. I had the gratification to accompany Sir Charles, together with Sir J. D. Hooker and the late Mr. King, of Saxlingham Rectory, to the Hotel des Bains at Cromer; and in the evening Sir Charles requested Mr. Symonds to join our party. The conversation turned on the Forest-bed, and Mr. Symonds mentioned that he had observed Sir Charles to pay particular attention to the annual rings of growth on the stumps or stools of the forest. I do not remember the precise place where, or the year when, this took place; but it is indelibly fixed in my memory that both Sir Charles and Mr. Symonds said they had seen the stools *in situ*.

I will mention one corroborative fact, which convinces me that the trees must have grown on the spot at Happisburgh, namely, the finding a large quantity of leaves imbedded there in a muddy ooze. These were seen by Dr. Falconer, by whose advice I had a large quantity conveyed to Irstead, and they were identified by Dr. R. H. Nathorst, an eminent Swedish naturalist, as the leaves of two varieties of willow. They must have fallen from trees which grew on the spot. The same may be said of the immense quantity of fir-cones which must have dropped from the trees. Dr. Falconer, with his characteristic sagacity, picked from the interspaces of the teeth of the *Rhinoceros Etruscus* some remnants of coniferous wood, observing that this showed what the Rhinoceros of the Forest-bed lived upon. Whether the animals and the trees of the forest lived and grew upon the spot where their remains are now found, and whether they are imported from some other unknown regions, I must leave to the judgment of the dispassionate reader.

10, CATHEDRAL STREET, NORWICH, JOHN GUNN.
June 11*th*, 1877.

GEOLOGY AND SCENERY OF NEWFOUNDLAND.

SIR,—When my friend Prof. Milne told me of the unfossiliferous character and monotonous aspect of the rocks of Newfoundland, the involuntary "shudder" of which he speaks was occasioned by feelings of commiseration for the geologist who should have his lot cast there, and not, as Mr. Murray seems to suppose, from any opinion concerning the absence of agricultural capabilities or picturesque features in the country. Since, however, I have had the opportunity of reading the valuable notes in your last Number, and studying Mr. Murray's valuable map, the sentiment of horror has been replaced by one of pride in the science which can manage to extract so much of interest even out of the "marshes, thickets, and swamps" of Newfoundland. JOHN W. JUDD.

ROYAL SCHOOL OF MINES, 18*th June*, 1877.

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No. VIII.—AUGUST, 1877.

ORIGINAL ARTICLES.

I.—Across Europe and Asia.—Travelling Notes.

By Professor John Milne, F.G.S.;
Imperial College of Engineering, Tokei, Japan.

(Continued from p. 297.)

Part II.—From St. Petersburg to Perm.

Contents.—St. Petersburg, its Public Buildings, Museums, Monuments, etc.—Moscow.—Nijni Novgorod.—River Volga.—River Kama.—Perm.

NATURE has by no means contributed her charms to the adornment of St. Petersburg. In fact, it is built upon a marsh, in a situation so flat that it is not until you have almost landed that you can see anything of this great city. The only object in choosing such a site appears in a sentiment of its founder, who wished to have "a window looking out into Europe." In some openings made in the streets and public gardens, I saw sections of from 15ft. to 20ft. thick, which gave some idea of the weak foundation on which certainly a large part of this great northern capital has been placed. It was all a bluish-grey sand. Beneath this sand I was told there was a bed of clay. But for this, if I may judge from the weak foundations which I saw, the look-out of the Russian Czar might by this time have entirely sunk from view.[1] The low situation of St. Petersburg, together with its marshy surroundings, at certain seasons gives rise to a mild malaria; and if you visit the city in summer-time, you will find that all the wealthy inhabitants have, in consequence, migrated towards the sea.

On the day after my arrival I paid a visit to the Government School of Mines, where there are about 450 students. Before entering, as at other higher government schools, the candidate must pass an examination or produce a diploma from one of the Gymnasiums which exist in nearly all the towns throughout the kingdom. He then enters upon a five years' course, paying about 30 roubles (nearly £5) annually. The system of education is very like that adopted in many other European Mining Schools, but very different from that which is followed out in the Government School of England,—many subjects being taught, and each one spread over a great number of years. In such a system a student, leaving before the curriculum is run, does so with a smattering of much, but with no thoroughness in anything. In such a case, or where it is desired by the student to become acquainted with only one or two of the many subjects which are discussed in Mining Schools, the English system, where one branch after another is successively commenced and ended, appears to be undoubtedly superior. At any period of his course a student may retire, and gain a benefit from the instruction he has received. Looking at the course of instruction which is appointed in the St. Petersburg School of Mines, there is an element of theory which strikingly preponderates. This is apparent not alone in theoretical subjects, but in those which would of themselves advantageously admit of practical application. Thus in Mathematics a first-year student must become tolerably master of the Calculus, but as a Zoologist he must become effete with lectures. Amongst the long list of subjects which are discussed, there are several, such as Jurisprudence, Statistics, Political Economy and Religion, which at other schools are only conspicuous by their absence. The painful way in which some subjects clash is also observable, —thus in one chamber the probability of kinship between men and apes is treated of, whilst in the next chamber such doctrines are dogmatically exploded. Overlooking these glaring inconsistencies, the political advantages of an ecclesiastical element in a semi-military school may perhaps be recognized.

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[1] Peter the Great, who, after dispossessing the Swedes, in 1702, of this neighbourhood, commenced, in the spring of 1703, to build the town, drafting annually 40,000 men from distant parts of the empire for this purpose.

The vacations, which are of about three months' duration, are spent in making geological surveys, attending metallurgical and other practical works. The preliminary training, such as is necessary for a mining engineer, being completed, the studies take a more decided form, and the students qualify themselves as geologists, metallurgists, or in that branch to which they may have devoted special attention.

Altogether the course is a severe one, as may be judged by making a comparison between the number of students in each of the five years. If there are 450 in the first year, about 400 are found competent to pass into the second year, 100 to the third, 60 to the fourth, whilst to the fifth there will not be more than 18 or 20. It is a hard gauntlet to run successfully. The course being completed, the student, before actually taking charge of works, may, if he desire it, proceed to some government works to further qualify himself, where he will receive a small salary.

In the School there is a large collection of models and of minerals. These latter are especially worthy of attention, as presenting, in the case of minerals peculiar to Russia, specimens which may in many cases be regarded as unique. A large block of malachite, weighing 29 cwt., said to be the largest ever obtained, at once strikes the attention. Besides this, I noticed several fine chrysoberyls. One of the clear ones was nine inches long, and from three to four inches in thickness. The emeralds and topazes are also conspicuous.

In the basement of the School there is a model of a mine, where the appearance of lodes, faults, and underground workings of various deposits are demonstrated in a manner intended to approximate to reality.

In addition to the jewels which may be seen at the School of Mines, there are others in various buildings and museums in the city, all of which are accessible to visitors. At the Winter Palace I saw the collection of Crown jewels. For size and number the display of diamonds, emeralds, and sapphires is perhaps unrivalled in any other court in Europe. A large spinel or ruby in the Imperial Crown is very conspicuous. The great Orloff diamond, weighing 194¾ carats, is also here. It has been suggested by Mr. Tennant that it once formed part of the same stone as the Koh-i-Noor. Its brilliancy, however, is not so great as might perhaps be anticipated: but this may, in part, be due to the form in which it has been cut.

Whilst looking at this rich and varied collection of gems, I was forcibly struck with the poor manner in which they are displayed. The rooms are bad, and generally ill lighted; whilst the cases, which were in accordance, afforded no protection whatever to their contents. By the taking of your hat and passport at the entrance to the building where these valuables are stored, one could not fail to remark, that any visitor who wished to make a sudden exodus, either from the room or from the capital, would be sorely inconvenienced.

In the city numbers of fine buildings meet the eye at every turn. Many of these, especially the churches and palaces, give some wonderful examples of modern masonry. The most conspicuous of these is St. Isaac's Cathedral. Here there are four porches, each of which is supported by double rows of tall cylindrical columns capped by Corinthian capitals. These columns, which are composed of red granite, are each 60 feet high and 7 feet in diameter. The steps leading up to these porches, each a single mass of granite, are equally striking, from their megalithic proportions. Inside the building there are many tall columns of malachite and several of lapis lazuli. These, however, are only columns with an external coating of those minerals; nevertheless, when they are seen, they serve to give an idea of the quality and quantity of these substances which have been obtained from Russian mines, and also serve to remind one of the insignificance of the displays of similar minerals in our own and other countries.

Although many monoliths have been used in the building of this Cathedral, isolated specimens of stone may be seen which are even larger. For example, there is the Alexander Column, which is a single shaft of granite 84 feet in height (originally 102 feet), and 14 feet in diameter. This, standing on a huge pedestal, and with its crowning capital, both of the same material, presents an appearance not less imposing than Pompey's Pillar at Alexandria. Besides this column, there is a block of granite on which rests an equestrian statue of Peter the Great, also remarkable for its size. It is calculated to weigh 1500 tons, and its original dimensions were 45 feet in length, 30 feet in height, and 25 feet in width. Its dimensions have, however, been somewhat reduced. This block, and many others which are to be seen in St. Petersburg, occurred as erratics in the vicinity of the town, very similar to those which I have referred to as being so plentifully distributed over Finland.

The scale on which so much of the masonry of this northern city has been carried out only finds its counterpart in that of ancient Egypt—massiveness and grandeur are displayed everywhere.

On the 15th of the month, which was Sunday, I visited the Museum of the Academy of Sciences, my object being to see a skeleton of the Mammoth, the remains of *Bytina Stelleri*, and some skulls of European Beavers.

The first of these, the Mammoth, I found, as I had often seen it depicted, standing side by side with the skeleton and a stuffed specimen of its modern representative, the Indian Elephant. In these pictures it is shown as a large monster with clubbed feet. Its relations look sensationally small, and the people who are regarding it still smaller. The clubbed feet are an inexplicable puzzle, and totally at variance with the rest of its bony framework and the toe-joints of its neighbours. In reality I did not find the imposing appearance which I had anticipated from picture studies. The room in which the skeleton has been placed is one that, if the creature were alive, it would find it, I believe, impossible to walk out of. It is neither high nor broad, has a dull gloomy appearance, and is piled up with many other remains. A lofty clear well-lighted apartment would greatly help in giving visitors a conception of the magnificent proportions of this ancient Elephant. As it is, they are presented to the framework of an animal so reared across a room that its tail almost touches one wall and its head the other.

On several parts of the skeleton, especially about the skull and hind feet, integument is still existing. There is also a covering on the right fore-foot, on which there is some thick red hair more than two inches long. The left fore-limb, if I remember rightly, and also the corresponding hind-limb are both cast from plaster, as also, I believe, many of the ribs. These feet, which have been cast to imitate the right fore-foot and its covering of integument, have given the club-footed appearance to the skeleton which is so often drawn without explanation. Several pieces of integument which belonged to this animal, from $\frac{7}{8}$ of an inch to more than $1\frac{1}{2}$ inches in thickness, are to be seen in the room, and also a fore-foot covered with skin half-way up the leg. The hair with which this creature was covered was like long red horse-hair. Although I subsequently saw many specimens of the integument of Mammoth covered with hair, I never saw any specimens with wool on them, such as are sometimes spoken of in books. The tusks seem to have belonged to another individual than to the one to which they are now attached, because the stumps to which they are joined are of much larger diameter than the tusks[1] themselves. This specimen is one which was discovered on the banks of the Lena in 1799.

The tusks which are supplied in such large quantities to the London market, to be used as ivory, come chiefly from the shores of the White Sea and the entrance to the River Petchora, where, as ɜea cuts its way back inland, large quantities of these valuable ıantine remains become exposed. Along the Siberian rivers, ɜspecially along the Obi and Lena, immense numbers of these .ins have been found. The Russians tell one that they are ı in such preservation that the natives eat of their flesh. Some e Jakutski and Tungusians who collect these bones obtain 20 to ›ubles (£3 to £4 10*s*.) per pood (40lbs.) for them.

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[1] See a similar statement, made on the authority of Prof. Maskelyne, GEOL. MAG. 1868, Vol. V. p. 541, in an article on the curvature of the tusks of the Mammoth.

ıe skeleton of *Rytina Stelleri*, of which the only other example be found in the Museum of Helsingfors in Finland, I could ind in the osteological collection to which the general public access. On explaining my wants, I was treated with every ness, and given facilities for seeing all I wished. The skeleton ›hich I was looking, together with many other skeletons, is kept chamber below the ordinary floor of the museum, which in arance is not unlike a store-room.

›e skeleton, which represents an animal more than 25ft. long, t altogether perfect, for the hand bones, if it ever had any, are and also one or two of the caudal vertebræ. A portion of the › gristly palate with which the creature was provided is also ɜrved. The rough transversely furrowed surface of this, which 'ered the purposes of mastication, is very curious. In places 'e the ribs had been cut into for purposes of examination, showed a fine white texture very like ivory. This specimen › from Behring's Isle, which in times past appears to have been ɜntral if not its only home. About a hundred years ago it was ficed, like the Great Auk and many other animals, to the gluttony wants of man, and is now to be regarded as one of the links be- n the past and present so often referred to by geologists at the nencement of their labours and historians at the end.

the same room as the one in which *Rytina Stelleri* is standing l an opportunity of taking a passing glance at the skulls of some ›pean and Asiatic Beavers. There are many animals inhabiting)ld World which bear the same name as those in the New World. has arisen from their general similarity in outward appearance. tities of this sort have been brought into question by naturalists, after various examinations, have found certain differences to between many American species on the one hand and Asiatic European species on the other, and the question apparently to be led, is whether these differences are sufficient to constitute a differ- in species. The case of the Beaver was one that was especially ght before my mind during my travels in Newfoundland, where companion, Mr. T. G. B. Lloyd, made a careful study of it, subsequently followed it up with the assistance of all such rial as could be found in the Museums of Great Britain. result of the comparisons as made, not only by Mr. Lloyd, also by various other investigators, seems to lie in the re- n existing between the length of the nasal bones and the skull. ' the rest of the framework of the animal was not taken into lly minute consideration I do not know, unless it was from the that such material was more difficult to obtain. Mr. Lloyd's results, as deduced from an examination of more than 30 European recent and fossil beavers' skulls, and a greater number of recent American skulls, seem to show that the proportion between the length of the nasal bones to the length of the skull in the European Beaver, is to the length of nasal bone to the length of skull in the American beaver as 6 is to 5. Or more mathematically—

$$\frac{\text{Length of Nasal Bones}}{\text{Length of Skull}}\ \text{European} : \frac{\text{Length of Nasal Bones}}{\text{Length of Skull}}\ \text{American} :: 6 : 5.$$

In a still simpler form the European Beavers have larger nasal bones than the American Beavers. The Beavers of both countries appear to have been contemporaneous with their gigantic predecessors, namely, the *Trogontherium* of Europe and the *Castoroides* of America, and the ancient giants had differences like their modern but comparatively dwarfish successors. Now what I saw of Beavers in the St. Petersburg Museum were two or three brownish-red stuffed specimens upstairs where the public go, and five skulls from localities from which specimens are rarely seen in the vault with *Rytina Stelleri*. These latter were the ones of interest. The first came from the River Kola, the second and third came from California, the fourth came from the Kurile Isles, whilst the fifth was from Sitka. Those with the shortest nasal bones were from the Kurile Isles and Sitka, then came one of the Californian specimens, then the specimen from the Kola River, and last of all, with the longest nasal bones, was the remaining specimen from California. Such a result as this is incongruous and at variance with the elaborate deductions just quoted. Perhaps American specimens west of the Rocky stuck together to represent grottoes, cottages, and other devices, which I think, from what I afterwards saw, must probably have been made in Ekaterinburg or its neighbourhood. All were very dear, and there were none of any great value.

After many difficulties, I found, amongst the dense black mass of barges and steamers which line the banks of the river, a boat which, on the following morning, was to start for Perm. As it was lying upon the south side of the river, I had opportunity to look at some high steep banks which rose high above us. Running horizontally along the face of this slope, which I have mentioned as having seen from the railway, there are many well-marked horizontal terraces. Two of these were very broad and flat. In several places the scarp or slope was cut through with small gulleys. These were utilized as roadways between the upper plane and the river. Where cuttings had been made, reddish-looking earthy sections, traversed with a few whitish bands, which looked like chalk, could be seen. The height of this scarp above the level of the river is about 240 feet, and the slope at the steepest part about 29°. At the top of this the country is flat. The red and white bands, both of which are apparently marly and without stones, are clearly visible up to about 180 feet. When dry, these materials break like a dried clay.

About 10 A.M. next morning, the whistle sounded three times, the captain gave his orders, and we pushed out into mid-stream. After doffing of hats, and crossing (I suppose for a favourable voyage), we started off in a driving rain against a head wind down the Volga.

All that I could now see of the river was by looking through the cabin window. Everywhere there are shoals of sand. On the north side of the river, where the banks were sufficiently cut into to show the stratification, long straight lines and sweeping curves could be distinctly traced. After a few miles, the scarp upon the south side, instead of looking as if it were only the sudden termination of a plain, merged gradually into a hill-like character. Both the hills and the scarp which now formed their face were of a red colour, and the white beds, which before had been at higher levels, were now only to be seen near the base. As we pushed on down the river, a long sandy shore crept in between us and the scarp. Towards the afternoon, as we travelled eastwards, the hills became less precipitous and scarp-like, until at last they had a rounded outline, and stripes of corn-fields diversified their sides. The islands in the river show sections of stratified earth or mud. Some of them are, however, sandy, and their light-coloured shores contrasted favourably with their dark-green cap of birch and alder. As night came on, the cold and drizzle, instead of ceasing, came on also. The hills upon the south side drew nearer to the river's edge, along which they continued pretty constantly. Those courses of the river which had the more northerly direction were, I think, bounded upon their southern side with the steepest banks. These still kept their red colour, and, where they had a few trees clinging to their sides, looked picturesque.

At 5·30 P.M. we stopped upon the south side of the river at a small village called Esad, to take in wood. The houses are built upon the side of a hill, but most of them occupy the first of a series of terraces with which it is furrowed. Numbers of wooden stairways join one portion of the settlement with the other. As the river has as many shoals beneath the surface of its waters as there are sandbanks which appear above it, two men are kept constantly at the bow to sound. This they do with a straight rod marked with alternate bands of black and white. Each sounding is called out. When the captain hears less than 3½ feet proclaimed, the signal to stop is given, and, if it is not too late, the vessel is run backwards and a new course is tried. Early next morning we ran into a small steamer and smashed its bows in. After this, many hours were spent in finding our way between sandbanks, often grounding with a shake and shock which on first experience was startling. From the style of navigation, it may be inferred that it is impossible to learn or place the courses of the river, which are ever being shifted by the silting up of channels and opening of others.

About midday, as we neared Kazan, we could see a few low hills away in the distance upon the north side of the river. On the south side the scarp, which had hitherto been red in colour, was now yellowish-white, and, instead of being earthy-looking, appeared more compact. Further on, these yellow beds were seen to underlie the red. Opposite to Kazan, a strip of low flat country marked the entrance of the River Swjaga, one of the feeders of the Volga. It flows from the south, and is very noticeable from the position it holds to the river to which it is tributary. Measured in a straight line, it is more than 150 miles long, and during the whole of this distance it flows parallel to, and only a few miles distant from the Volga, which it feeds—but, strange to say, in an entirely opposite direction. Whilst the Volga flows south, the Swjaga flows north. At more than 100 miles above their confluence, the two rivers come so close together that they are indicated upon the map as flowing through the same town of Simbirsk. Although rivers of this sort are exceptional, they give us hints of the difficulties which explorers may meet with in unknown countries when working out their topographical details.

After passing the flat opening, we again had the hard whitish cliffs upon the south, the red colour appearing at last to be entirely lost. By disintegrating agencies acting along the lines of stratification, horizontal ledges have been left protruding. Although these are not very well defined, they are yet sufficient to form a foothold for small trees and bushes, which now form dark lines along the face of the cliff. The water of the river here was apparently the same as it had been at Nijni Novgorod, so charged with sediment as to be of a dirty-yellowish colour.

Next morning I awoke to find that during the night we had broken down, and were quietly lying alongside a hulk at a small station called Cheestopol, at the entrance of the River Kama. As we were detained here until evening in making repairs, I had a ramble amongst the woods near the shore. Elm, oak, and birch were the common trees; I did not see any spruces or pines. Butterflies and other insects were taking advantage of a few gleams of sunshine, and I had great sport amongst them.

The current of the Kama is a little more rapid than the Volga, and here, with the wind blowing against it, it was curled up and flecked with patches of white foam. Our repairs being ended, we started up the Kama. We had, however, not been very long afloat, when, through running on a sandbank, our machinery again gave out, and we were detained for the remainder of the night. Next day we were again afloat. Upon our western side an occasional red cliff was to be seen, whilst nearer to the river brownish earthy banks were well marked with lines which showed the height to which the water sometimes rises.

During our second evening on this river an immense number of delicate white ephemeral-looking flies fell upon our deck and into the water. These were so thick in places that they fringed the windward shore of the river with a white line. On the Dneiper a somewhat similar fly sometimes occurs in such quantities that the fishermen light fires to attract them. The creatures, whilst hovering round the light, get their wings singed, and fall down on and round the fire like snow. They are then swept together, mixed with clay, and used for ground bait.

A passenger on board, a man apparently of some intelligence, told me that mineral coal had been found on the Kama near Piani-Vor. If this is proved to be correct, it will not only give a new locality for the mineral, but also another point for the outcrop of the Carboniferous formation. In the Kama there are a few low islands, which take the place of the sands I saw upon the Volga. With this exception, I do not think that there is any choice, as far as picturesqueness is concerned, between the two. As a whole, they are both flat and dull. As we progressed upwards, we saw some pleasant upland slopes chequered over with square plots of cultivation. In outline these hills are not unlike our downs, but they are perhaps more furrowed by the small streams which cut through the soft red Permian strata of which they are composed. The shore is everywhere slippery and muddy. As we neared Perm, we had upon our western side high sloping hills of red earth bounded with white rock.

On the afternoon of Thursday, September 3rd, we came in sight of Perm, and in the afternoon we landed, after a wearisome eight days' steaming along two rivers, which, for flatness and monotony, would rival, I think, any in Europe.

(*To be continued in our next Number.*)

II.—A Sketch of the Geology of Keighley, Skipton, and Grassington.[1]

By J. R. Dakyns, M.A., of H.M. Geological Survey.

In Derbyshire the Millstone-grit series consists of four or five well-marked grits, separated by shales, viz. the so-called first or topmost grit, named, from its coarse character, the rough rock;

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[1] Originally read with the Director's permission before the British Association at Bradford, but not heretofore published.

he second grit, which is generally a flagstone; the third grit, a bold, well-jointed rock; and lastly, the Kinder Scout grit, which ometimes consists of two beds. In advancing northwards this ype undergoes considerable changes; the second grit becomes merely a basement bed to the rough rock, not always separable herefrom; the third grit loses its massive character, and other beds of sandstone begin to show themselves amid the shales overying the Kinder Scout grit. When one reaches the valley of the Colne, four separate sandstones have developed themselves between he rough rock (locally known as the sand rock) and the recognized Kinder Scout grit. This type prevails also in the valley f the Yorkshire Calder; but is not to be found on crossing the watershed into the basin of the Aire. There the series consists in escending order, first of the rough rock, which throughout maintains ts usual marked character till it is buried beneath the Permian; econdly, of a very variable basement bed to the last, consisting, when well developed, of valuable flagstones. These are extensively quarried at Nab, above Oxenhope Moor; and also in an outlier at he Penistone quarries, near Haworth. Below this bed comes a resh series of variable sandstones and shales. There may be in places as many as fifteen or sixteen distinct sandstones below the basement of the rough rock and the regular Kinder Scout grit. But his set of beds may conveniently be divided into two by means of a onspicuous grit which is continuous with the third grit of Lancashire. This grit forms the bold escarpment of Hallan Hill and Earl Crag, o conspicuous with Wainman's monument on its crest, as seen from he railway between Keighley and Skipton. We may conveniently peak of it as the middle grit. It generally has three grits between t and the base of the rough rock; these four beds are presumably he four grits of the Calder and Colne valleys mentioned above. I will now briefly point out the general run of the beds in the basin of he Aire. The rough rock runs in a nearly unbroken manner from he latitude of Penistone, and enters the basin of the Aire above Oxenhope Moor; its basement flags form the lofty escarpment of Nab, whence may be had a glorious view of the northern fells from ngleborough on the west to Great Whernside on the east.

A large fault, ranging across Thornton Moor in a W.N.W. direcion, throws down the Coal-measures of Denholme on the north, from beneath which the rough rock rises to form Black Moor and Brow Moor. Another W.N.W. fault throws the beds up again near Cullingworth, so that Harden Moor, between Bingley and Keighley, consists of an outlier of rough rock, while various members of the hird grit series occupy the flanks of the hill. West of the river Worth the rough rock forms, with a dip slope, the wide expanse of Keighley Moor; but at Exley Head another W.N.W. fault throws up the beds to the north, so that an outlier of rough rock forms the hill on which is situated Keighley tarn. Going N.W. from the town we pass successively over the various members of the third grit series. The middle grit can clearly be traced by its massive character running down to the valley south of Hawkcliff Cottage; it ascends on the north side of the Aire. somewhat broken by faults, and forms Brunthwaite Crag; is thrown up by a W.N.W. fault to form White Crag, and again in the escarpment of Addingham High Moor. It is this rock which forms the well-known Brimham Rock near Pateley Bridge. Below the escarpment of the middle grit there is no conspicuous rock south of the Aire; but on the north of that river several beds of sandstone appear, one of which becomes important further north as the hard siliceous grit with ganister, which forms the summit of Great Whernside. Owing to the number of sandstones that now have come in, it is somewhat uncertain what ought to be taken as the top of the Kinder Scout grit, though there is no doubt about the main mass of the bed. This well-marked, coarse, and massive grit is brought in by a W.N.W. fault (south of the river Aire), which is remarkable as one of the few instances in which galena has been found away from the limestone area. North of the Aire the Kinder Scout grit rises up regularly from beneath the overlying beds at Kildwick. Near Cononley a N.E. fault throws down the beds on the N.W., so that the upper part of the Kinder Scout grit is again found in the valley. The bed here consists generally of three separate rocks. It is immediately underlain by a thick but variable set of sandstones, with shale partings, which have hitherto been styled Yoredale grits; but this is a very bad and misleading term, as the beds are merely the basement part of the Kinder Scout grit, from which they cannot always be separated without forcing; and, moreover, these grits are nowhere, that I know of, found in Yoredale. Beneath these are found, at Skipton, shales and limestones, a narrow band of contorted limestone, forming the crest of an anticlinal, appearing between the road and railway about half a mile south of Skipton. The strike of the beds hitherto described is generally N.E. and S.W., the dip increasing as we go westward; but about the latitude of Skipton the beds bend round so as to strike nearly E. and W., with a dip of 20 deg. to the south along Skipton Moor. In fact, the country between the latitudes of Skipton and Grassington has been much disturbed and thrown into a series of east and west rolls. Thus a strong anticlinal ranges down the Skibeden Valley from Skipton to Bolton Abbey, with a steady dip to the north, and many minor folds on the south. The effect of this is that a mass of Mountain Limestone forming the green boss known as the Haw Park has been brought up in the Skibeden Valley between two ranges of Millstone-grit hills, viz. Skipton Moor on the south, and Embsay Moor on the north. The Mountain Limestone here is a dark thin-bedded limestone. It is extensively quarried for road material both at Haw Bank and also at Thornton, where similar beds are found. Either of these quarries is well worth a visit. The beds are much faulted and contorted, particularly along the south side of Skibeden Valley; good instances of contortion are to be seen at Draughton and the Wheelam Rock quarries, as also at the Hambleton Rock quarry, near Bolton Bridge; an excellent section of contorted beds is also to be seen in Halton Gill. The strike of the beds of Mountain Limestone seems to indicate that they have partly been brought up by a fault ranging along the south side of the Skibeden Valley;[1] but on the north they dip regularly under the Yoredale and Millstone-grit beds. On that side, where the series is much clearer than on the south, there are two limestones above the Mountain Limestone. On the south side of the Skibeden Valley and anticlinal the Kinder Scout grit strikes E. and W. along Skipton and Draughton Moors, and descends to the river Wharfe north of Addingham. Its high southerly dip carries it up the slope of Langbar Moor, it base running just below Beamsley Beacon; it then, under the influence of a branch of the Skipton anticlinal, plunges down northward to Kex Beck, where the beds bend up again and rise northward to Hazlewood Moor and Bolton Park; here, on the strike of the Skipton anticlinal, the beds bend over northward and recross the Wharfe below Laund House; south of this, as far as Bolton Abbey, limestones and shales of the Yoredale series are seen along the river. These are cut off opposite Bolton Abbey by a N.E. fault bringing in the upper beds. The so-called Yoredale grits run along the slopes of Skipton Moor to Fairfield Hall; and east of the Wharfe are found about Beamsley and Storriths. They have not been everywhere identified on the north side of the Skibeden Valley. On the west side, though the beds are in several places broken by N.W. faults, yet their general run is tolerably plain. A set of bold crags marks the escarpment of the Kinder Scout grit along Halton and Embsay Moors, Rylstone, Burnsall, and Thorp Fells. Beneath the western escarpment of the Kinder Scout grit, the Yoredale grit is found forming at intervals promontories on the sides of the fells, probably caused by a local hardening of the rock, which appears to be of a very variable character. It has not been traced further east than the northern extremity of Burnsall Fell. The Kinder Scout grit, whose escarpment has been briefly indicated above, lies in the shape of a synclinal trough dipping east, and thus occupies with its various members the whole extent of Burnsall Fell, Barden, and Embsay Moors. The rock is well seen along the river Wharfe, particularly at the celebrated 'Strid' in Bolton Woods. On the east of the Wharfe these grits rise up in a sort of broken dome with a quaquaversal dip to form the summit of Barden Fell, well marked by the bold crags of Simon Seat, whence a magnificent view is to be had, and York Minster may be seen on a clear day. Near these crags, at the very summit of the fell, 1700 feet above the sea, some pot-holes (one of which, in the dialect of the country, is, from its great size, called the Great Shak) indicate the presence of limestone at no great distance. The beds may be seen in Howgill and on the path through Fell Plantation, dipping steeply to the N.W. into the valley; but along the Skyreholme beck they turn up again, and dip steeply to the S.E. From Appletreewick the grits are seen striking north-eastward, underlain by a mass of shale, from beneath which massive white scar limestone rises regularly with a similar strike, as far as a set of bold crags, marked by the Ordnance station, 1350 feet above the sea-level; here the beds end abruptly, being cut off by the Craven fault. The position of this fault is also shown by the abrupt termination of similar grit crags at Fancarl, by great disturbances of the beds at Thurskell Well, near Hebden, and by disturbed beds on the banks of the Wharfe near Lyth House, whence the fault runs by Skirethornes, with limestone on its north side and grit on its south, to join the line of bold cliffs which mark the line of the fault from Malham to Settle. East of the river Dibb we have, north of the Craven fault, massive white limestone, dipping north at 19°, closely overlain by the grit of Grimwith Fell, from which the main mass of limestone is separated merely by a thin band of mixed shales and limestones. The green mass of Greenhow Hill forms the dome-shaped end of this band, which is in fact an anticlinal, broken up by the Craven fault. Between the river Dibb and Grassington the ground is very obscure; but the Millstone-grits seem to be separated from the great limestone by a considerable thickness of shales, with but poor limestone bands. At Grassington, however, the limestones swell out, and with the exception of two bands of hard sandstones, known as the Dirt Pot Grits, there is solid limestone from the grits of Grassington Moor to the river Wharfe. Northwards the limestone gradually breaks up, and finally takes on the Yoredale type, so well known from the writings of Professor Phillips.

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[1] I now consider it doubtful whether there is not also a fault along the north side of Skibeden.

III.—NOTES ON THE CORRELATION OF THE BEDS CONSTITUTING THE UPPER GREENSAND AND CHLORITIC MARL.

By A. J. JUKES BROWNE, B.A., F.G.S.;
of H.M. Geological Survey.

CONSIDERABLE uncertainty has for some time existed with regard to the formations known by the names of Upper Greensand and Chloritic Marl.

The series of beds which are thus denominated have been accurately described as they exist in several different localities, and the strata supposed to constitute these divisions have been shown to vary greatly both as regards their lithological characters and their fossil contents; but very few attempts have been made to ascertain the lateral extension and the exact stratigraphical relations of these component beds; they have been like the fragments of a puzzle which no one has succeeded in putting together.

Geologists, indeed, were for a long time contented to receive all the sandy and glauconitic deposits intervening between the Gault-clay and the Chalk-marl of any locality in England as belonging to the Upper Greensand. Afterwards, when the Chloritic Marl was separated from the series in the Isle of Wight, its existence in other parts of England was not properly established—or, to speak more correctly, different inland horizons were assigned to it by different writers.

The type of the Upper Greensand was supposed to exist in

Hampshire and the Isle of Wight, and it was said to assume different facies in other districts; thus the Blackdown Beds, the Warminster Greensand, and the Cambridge "Coprolite Bed," have all been referred to the Upper Greensand, and have been considered as local developments of that formation. It is true the two latter have also more recently been called Chloritic Marl, but this only shows the uncertainty attending the use of that term, and the general opinion has been that they were all "Upper Greensand"; the great differences between the above-mentioned deposits being accounted for by the relative distances from contemporaneous land and other varying geographical conditions.

It was known that these Greensands contained very different fossil faunas, but no one had followed up the beds possessing any of these local faunas, nor had the fossils even from the separate beds of one locality been collected with the view of ascertaining whether the succession of strata contained the same fauna from top to bottom. Such investigations must inevitably have led to more accurate views, but the valuable evidence afforded by the fossils was to a great extent ignored, and the more obvious differences were explained away in the manner above mentioned; explanations which in themselves suggest very interesting questions, but which are inadequate to account for all the circumstances of the case.[1]

Within the last few years, however, the Cretaceous system has been more carefully studied both in England and France, and the Greensands have received their due share of attention; the stratigraphical details of the several divisions have been investigated by men who were at the same time careful to pay attention to the palæontological evidence, and it is now possible to answer most of the questions above indicated as obscure or unknown.

The result of these inquiries has been to alter very materially our conception of the importance of the Upper Greensand and Chloritic Marl, and to render it very doubtful whether they should continue to rank as divisions of primary importance in the Cretaceous series.

It is perhaps the position of the Chloritic Marl which is at present the most doubtful and undefined. Mr. C. J. Meyer has claimed for it an importance equal to that of the Upper Greensand, while Mr. Whitaker has expressed himself as objecting to the term altogether on the ground of its being nowhere satisfactorily defined, but applied in one place to Upper Greensand and in another to Chalk.

Again, in the March Number of the GEOLOGICAL MAGAZINE, p. 123, the reviewer of Mr. Bonney's "Cambridgeshire Geology" takes exception to the application of the term Chloritic Marl to the Cambridge Greensand, and in the April Number, p. 191, Mr. H. G. Fordham expresses surprise at this, and wishes to learn what may be taken to constitute "the true typical Chloritic Marl."

It seems therefore that it would be useful to give some general account of all the Glauconitic, or mis-called Chloritic, sands between the Gault and Chalk-marl, and to review some of the conclusions arrived at by different writers on the subject, in order that the way may be paved towards the establishment of a better nomenclature, and a more natural classification in this part of the geological series.

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[1] These arguments have been recently renewed by Mr. Seeley, but without the support of any additional observations, and in the face of the facts brought forward by Dr. Barrois and myself.

THE UPPER GREENSAND.

The early history of this formation is chiefly connected with that of the Wealden area, where the Firestones and Greensands below the Chalk had attracted attention in the beginning of the present century; it was to these I believe that the term "*Greensand*" was first applied: thus in William Smith's Memoir (1815), the succession of the strata is correctly given as follows:

Chalk (Upper and Lower).
Greensand parallel to the Chalk.
Blue marl (viz. Gault).
Kentish Rag, etc.

This last, however, and some other beds between the Gault and Weald Clays, being likewise of a green colour, came also to be spoken of as "the Greensand." Thus Conybeáre and Phillips, in 1822, showed the Firestone-beds of Merstham to be distinct from *the Greensand*, and separated therefrom by a blue marl which they doubtfully refer to the Cambridge Gault. They also distinguish the [Lower] Greensand from the Hastings beds of the Weald, then called "Iron sand"; but they do not make the same distinction in the Isle of Wight, where their Greensand is the Upper Greensand.

It was left for Fitton, in 1824,[1] to finally clear up doubts and difficulties which attended the correlation of the Greensands and the Iron sands, and by him the whole series was correctly described both in the Wealden area and in the Isle of Wight.

It being thus proved that there were two horizons where beds of Greensand occurred, viz. above and below the Gault or "Blue marle," it was natural that these should come to be called the Upper and Lower Greensand. Sir R. I. Murchison seems, however, to have been the first who actually made use of the name in any published paper: this being in his Memoir on West Sussex, read before the Geological Society in 1825.

Mr. Martin adopted the name for the beds in the northern part of the Weald, and Dr. Fitton in 1836 for those in the Isle of Wight and the south-east of England. The name was thus accepted as designating all the sandy beds between the Gault and Chalk-marl, and was a division founded purely on lithological characters, and without any reference to the fossils which its several component strata contained.

The first attempt to estimate accurately the thickness of the Gault and Greensands is recorded in the Quart. Journal for 1845 by Mr. J. W. Simms,[2] the following section being measured between Atherfield Point and the cliff south of St. Catherine's Down:—

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[1] Ann. Philos. ser. ii. vol. viii. pp. 365 and 458.

[2] Quart. Journ. Geol. Soc. vol. i. p. 77.

		Feet	
Upper Greensand	Parallel layers of soft rock and of hard cherty sandstone	37	
	Sand with layers of stone and chert	67	
		—	104
Gault	Light-coloured Gault becoming bluer	43	
	Beds of decided blue colour	103	
		——	146
Lower Greensand in various beds			——
			250

These measurements and divisions, although apparently taken with great care, do not seem at first sight to correspond with those given in the Survey Memoir on the Isle of Wight; but it is remarkable that the combined thickness of the Gault and Upper Greensand should be estimated in both at exactly the same amount, viz. 250 feet. Of this, 150 feet are assigned to the Greensand by the Geological Survey, including 50 feet of clayey micaceous sands at the base. Now I think it is not improbable that these are the "light-coloured Gault" mentioned in the above section, which, if added to the other beds, makes the thickness very nearly the same, viz. 147 feet. This is of course a conjecture; but as they are certainly passage-beds, it would not be surprising to find them placed in the lower formation by some authors, and in the higher by others.

Captain L. L. B. Ibbetson seems also to have excluded these beds, when he states that the Upper Greensand is about 100 feet thick;[1] he does not mention the locality where this was measured, but he gives a detailed list of the strata observed in descending order; as this has never been reproduced elsewhere, I give the following abridgment of it:—

	ft.	in.
1. Zones of Chert and Rag, with *Pecten orbicularis*, *P. 5-costatus*, *Serpula concava* and *Siphonia*	15	0
2. Conglomerate of Chert and Rag (much rolled)	4	0
3. Bands of Chert and Firestone...	5	2
4. Freestones separated by layers of Rag	11	6
5. Rag and Malm alternating	16	8
6. Mammillary Rag, round Chert, sandy boulders, with phosphate of lime (? nodules)	1	6
7. Malm and Rag...	6	8
8. Fossiliferous Malm	3	0
9. Malm and Rag, with numerous *Serpulæ*	40	0
	103	6

The close agreement of this section with that of Mr. Simms is made more apparent if it is still further abbreviated thus:—

	ft.	in.
Zones of Chert, Firestone and Freestone	35	8
Alternations of Rag and Malm...	67	10
	103	6

and it is possible therefore that the thicknesses were estimated at the same place, viz. at St. Catherine's Down.

About the same time (1848) Messrs. Paine and Way published an important paper on the Phosphatic Strata of the Chalk Formation,[2] and were, I believe, the first to point out the threefold division of the Upper Greensand as developed in Hampshire and Surrey. They say: "It commonly comprises three distinctive formations; the first is a thin green band of marl, more or less siliceous, and abounding in organized fossil remains; it lies below and in contact with the soft dirty white marl above mentioned; in thickness it varies from a few inches to 10 or 15 feet. The second division is the firestone rock, the thickness of which also varies. . . . This rock gradually merges into a soft clayey marl, which constitutes the third sub-division, and this again in its inferior parts becomes more and more argillaceous, until it is finally lost in the Gault." Mr. Godwin-Austen, writing in the same year, makes a similar division of the series near Guildford,[1] but refers the lowest green marls and clays containing phosphatic nodules to the Gault.

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[1] Notes on the Geology and Chemical Composition of the Various Strata in the Isle of Wight, London, 1849.

[2] Journ. Roy. Agric. Soc. ser. i. vol. ix. p. 56.

Here, again, there is no definite base-line for the Upper Greensand, and certain clayey marls are referred by one observer to the Gault and by others to the Greensand; it will be seen in the sequel that I look upon the former mode of grouping as the most correct.

In 1862 two memoirs were published by the Geological Survey describing the Isle of Wight and parts of Hampshire and Berkshire (Sheet 12); no detailed sections of the Gault and Greensand are given in either of these works, but the following may be deduced from the description on p. 24 of Mr. Bristow's "Isle of Wight," and may be compared with those on a previous page.

	Feet
1. Calcareous Sandstone	20
2. Chert, Sandstone, and Freestone	? 16
3. Sands and Sandstones	? 24
4. Yellowish-grey sand with some Sandstone and Chert (? Rag) ...	40
5. Bluish sandy micaceous beds...	55
	155

It is to be regretted that the fossils found in these beds were not given separately instead of being combined into a general list.

As regards the base-line, Mr. Bristow says (p. 23): "Sometimes the Gault assumes a very sandy character, and passes so insensibly into the Upper Greensand as to be scarcely distinguishable from it." A section also is given showing the passage from Gault to Greensand, and the bluish sandy clays are stated to contain *Gryphæa vermicularia* and *Arca*; the line is mainly drawn to separate sands from clays, the sandy clays being mostly included with the Upper Greensand, and not with the Gault (see antè).

In the Memoir on Sheet 12 the Upper Greensand is described as consisting of the same three divisions previously indicated by Messrs. Paine and Way, viz. (1) Greensands; (2) Malm rock; (3) Soft sandy marls; but the former of these is referred to the Chloritic Marl, leaving the other two only to constitute the Upper Greensand.

Thus we find that there is great uncertainty both concerning the upper and lower limits of the formation, and that the only beds which all agree in calling Upper Greensand are the Malm-rock and

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[1] Quart. Journ. Geol. Soc. vol. iv. p. 257.

Firestone of the Wealden area, and their equivalents of Firestone and Cherty Sandstone in the Isle of Wight. The Warminster Greensand has also been generally accepted as another type of the Upper Greensand, and of its claims more will be said hereafter.

THE CHLORITIC MARL.

By whom this name was first proposed, and to what bed or beds it was first applied, I have been unable to determine with any certainty, nor have the several geological friends whom I have consulted been able to enlighten me on the subject. It seems probable indeed that in its first application it was used rather as a descriptive term than as a designation for any particular bed, and simply as a translation of the French "Marne chloritée."

Thus the earliest paper which takes cognizance of it is one by Mr. Godwin-Austen on the geology of the south-east of Surrey, 1843.[1] After describing the Lower Chalk of this district, he says, "This portion of the series, taken in a descending order, slowly acquires an admixture of sand and green earth, so as to become first a *craie chloritée*, till by the further diminution of the calcareous matter we reach the bright green beds of the Upper Greensand with *Plicatula inflata*."

This *craie chloritée* appears to coincide in position with what was afterwards called the Chloritic Marl; but a paper written in the ensuing year by Prof. Forbes and Capt. L. L. B. Ibbetson, contains the first actual mention of the term that I have been able to find, and in this a more indefinite location is assigned to it.[2] The authors describe the Cretaceous system as seen in the Isle of Wight between Sandown and Whitecliff Bays, and the following passage occurs: "The Upper Greensand corresponds nearly to the section at St. Catherine's Down, presenting successively sands and clays, under the name of Chloritic Marl, siliceous bands, firestone and freestone, malm and rag, the malm in a 3-feet bed, highly fossiliferous, surmounted by 26 feet of malm and rag passing into Chalk Marl."

The whole description is somewhat confused; but if any particular beds are meant to be indicated by the name of "Chloritic Marl," they would appear to be sandy marls and clays overlying the Gault-clay, and forming the passage-beds to which I have previously alluded. The authors may, however, have been mistaken in their identification of the horizon, or they may have merely meant the term to be descriptive of the lithological character of the beds.

However this may be, the term Chloritic Marl had apparently been associated with strata at the top of the Greensand or base of the Chalk Marl before the year 1848, and by this time the authors above mentioned had arrived at more definite views regarding it. Captain Ibbetson read another paper before the British Association in this year "On the position of the Chloritic Marl or Phosphate of Lime-bed in the Isle of Wight,"[3] the substance of which was included in his little book on the Strata of the Isle of Wight previo cited. In these publications he does not appear to propose application of the term to this bed for the first time, although i probable that its position was now first clearly defined; he t speaks of it at p. 21:[1]

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[1] Proc. Geol. Soc. vol. iv. p. 169.

[2] Brit. Assoc. Rep. Trans. Sec. 144.

[3] Brit. Assoc. Rep. 1845, Trans. Sec. p. 69.

“The Chloritic Marl or principal phosphate of lime bed co next in succession and divides the Chalk Marl from the Up Greensand. It is a grey marl full of green grains of a silicat iron and sand, very fossiliferous. The upper part in places exhi a conglomerate of pebbles and small boulders, and in it the fos are chiefly broken as if rolled on a beach. The lower beds cont the fossils whole and appear to have been formed in still wa *Ammonites varians* and *splendens*, and *Scaphites striatus* are most characteristic fossils, but it also contains abundantly nodule a coprolitic form, composed of from 15 to 28 per cent. of phosph of lime.”

The bed is stated to vary in thickness from one to three feet, a to occur all round Shanklin and St. Boniface Downs directly un the Chalk Marl; a list of other places where the stratum is obse able is also given.

Nothing is added to this description in the Geological Surv Memoir of 1862, except a fuller and more accurate list of foss Mr. Best informs me that the term Chloritic Marl appears to ha been first adopted by the Survey during the year 1856, as it is n mentioned in the Index of Colours for that year, but is contained the first edition of the Catalogue of Rock Specimens published ea in 1857. It may, however, have been used in the field before t date, and Prof. Forbes is by tradition accredited with the recogniti of the fact that its fauna, though peculiar, links the bed rather wi Chalk Marl than with the Greensand below; probably this was b tween the years 1844 and 1848, as Prof. Forbes comments upon t list of fossils originally appended to Capt. Ibbetson's paper in th year. Capt. Ibbetson also refers to Messrs. Austen and Nesbit having mentioned the occurrence of the Chloritic Marl at Guildfo and Farnham respectively. These gentlemen in 1848 had indicat the exact position occupied by the several phosphatic beds in t Cretaceous series of Hampshire and Surrey,[2] and although the papers do not contain any actual mention of the marl, it is suf ciently evident that one of the phosphatic beds lies in the uppermo green marl described by Messrs. Paine and Way as varying in thic ness from one to fifteen feet, and that this is much on the sa horizon as the bed identified by Capt. Ibbetson.

This was also the view taken by Messrs. Bristow and Whitak in their Memoir on Sheet 12 (1862), where the Chloritic Marl mentioned as occupying a narrow band at the base of the Cha Marl, overlying the Malm Rock, and varying in thickness from few inches to ten or fifteen feet. Sections of this marl are also scribed in the later Memoir on the Weald by Mr. Topley, who pref to class it with the Upper Greensand, but remarks that—"In the Memoir on Sheet 12 this bed was described as Chloritic Marl, and was classed with the Chalk. This was done at the suggestion of Prof. Edw. Forbes, because in Dorset and in the Isle of Wight *Scaphites*, etc., were supposed first to appear in a bed which is considered to be the same as this." To this difference of opinion I shall have occasion to refer again presently.

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[1] Notes, etc., on the Strata of the Isle of Wight, London, 1849.

[2] Quart. Journ. Geol. Soc. vol. iv. pp. 257 and 262.

There is another district in which a bed has often been described as occupying a similar position; this is the outlying area of Cretaceous beds in the counties of Devon and Dorset. Mr. Davidson, in his Monograph of the Cretaceous Brachiopods, gives the following succession as seen in the neighbourhood of Chard and Chardstock:[1]—

I. *Lower Chalk* without flints.
II. *Chalk Marl*, with fine siliceous and chloritic grains, and *Am. Mantelli*, *Discoidea cylindrica*, *Hol. subglobosus*, etc.
III. *The Scaphites Bed*, 3 to 9 inches thick, a compact accumulation of fossils and siliceous grains—*Scaphites*, *Nautilus triangularis*, *N. lævigatus*, *Am. varians*, etc.
IV. V. VI. The Upper Greensand in three beds.

This "Scaphites bed" is evidently the analogue of the Chloritic Marl, and the bed below is described as distinctly separated from it.

In 1870 Mr. Whitaker divided the Upper Greensand of Beer Head from glauconitic beds above, which he doubtfully referred to the Chalk Marl, and which he showed in an accompanying section as overlapping the lower strata.[2] Mr. De Rance afterwards made a further subdivision of the beds in West Dorset, establishing a succession of five different zones.[3]

I. Zone of *Scaphites æqualis.*
II. Zone of *Pecten asper*, 20 feet.
III. Zone of *Exogyra conica*, 15 feet.
IV. Fox-mould, 60 feet.
V. Cowstones (? 40 feet),

The first of these he considers to be the Chloritic Marl, and the last he refers to the Upper Gault, leaving the three middle zones in the Upper Greensand.

In the same year Mr. C. J. A. Meyer published a paper on the relative horizons of the Warminster and Blackdown deposits,[4] in which he divides the beds of the Beer Head district into a number of zones, and groups these into four larger divisions, viz. the Blackdown beds, the Upper Greensand, the Warminster beds and the Chalk Marl, thus limiting the Upper Greensand still more by separating from it the Warminster beds or *Pecten asper* zone, reducing it indeed to little more than the equivalent of the *Ex. conica* zone of Mr. De Rance. Speaking of the Warminster beds he says, "They are seen to cap the Upper Greensand, and are therefore in reality Chloritic Marl," a conclusion which he considers to be borne out by the evidence of the fossils.

As however the fauna of the Warminster beds has subsequently been found in the Upper Greensand of the Isle of Wight below the

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[1] Pal. Soc. Mem. 1852, p. 114.
[2] Quart. Journ. Geol. Soc., vol. xxvii. p. 98.
[3] Geol. Mag. Dec. II. Vol. I. p. 196.
[4] Quart. Journ. Geol. Soc. vol. xxx. p. 369.

Chloritic Marl, it is evident that this identification is not correct that these beds must be restored to the Upper Greensand.[1]

The mistake was probably caused by the existence of *rem* fossils from the Warminster beds in the Chloritic Marl of the of Wight, imparting to its fauna the semblance of that below; appears to be also the case with its probable equivalent in the De shire section, namely, that numbered 13 by Mr. Meyer, whic describes as resting upon an uneven surface of the bed below, as containing numerous phosphate nodules and casts of shells, of which he regards as having probably been derived from the er of the beds below. He rightly considers this bed as forming base of the Chalk Marl, and remarks upon the importance o line formed by its marked separation from the Warminster beds

The paper indeed is a valuable one, for though mistaken in particular, he correctly states the infra-position of the Blackdov the Warminster beds, and of the latter to what is really the Chl Marl; the true relations of these beds had not before been a tained, and the lists of fossils afford the means of determining recognizing the beds over a larger area.

I have previously drawn attention to the similarity between conditions presented by the base of the Chalk Marl in Devon and those observable in the Cambridge Greensand;[2] there ca think, be little doubt that the two beds occupy exactly the horizon, and that the fossil contents of both are to a greate less extent *remaniés*. There is, however, this great difference tween the two sets of derived fossils, viz. that the one of was derived from the fauna of the Warminster beds, and the from that of the Upper Gault; the reasons of this difference I also fully explained.[3] The Cambridge bed has been describe Chloritic Marl by the Rev. T. G. Bonney in a paper read b the Geologists' Association in 1872,[4] and more recently in his bridgeshire Geology, but without distinctly comparing it to Chloritic Marl of the Isle of Wight; in the former paper, in he was inclined to regard it as to some extent the equivalen the Upper Greensand, but adds at p. 19, "It must, howeve remembered that, probably, our Cambridge bed is rather h taxial than absolutely contemporaneous with some at least o more western developments of the South of England Upper G sands." I think, however, I am not misrepresenting Mr. Bon present views in saying that he concurs with me in considering Nodule Bed as forming the actual base of the Chalk Marl, therefore, as the exact equivalent of the Chloritic Marl accor to its more recent definition.

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[1] See Barrois, Sur l'age des couches de Blackdown, Ann. Soc. Geol. du tom. iii. p. 7.

[2] Quart. Journ Geol. Soc., vol. xxxi. p. 272.

[3] The fact of the entire absence of the characteristic fossils of the Warminste in the Cambridge Greensand is sufficient proof that these beds were never dep in that area, *loc. cit.*, pp. 272, 273.

[4] Proc. Geol. Assoc., vol. iii.

DR. BARROIS' CLASSIFICATION.

Having now reviewed the various descriptions and definitions hich have been given of the Upper Greensand and Chloritic arl up to the year 1875, I proceed to notice those given in the cently published researches of Dr. Ch. Barrois,[1] which have, I nceive, gone far towards harmonizing the conflicting opinions reviously existing with regard to the constitution and imortance of these beds, and towards establishing a more natural ethod of grouping the strata in this portion of the Cretaceous ries.

In this work Dr. Barrois has shown that a proper understanding the Cretaceous system (as of all other systems) can only be tained by one who unites the qualifications of a palæontologist ith those of a field-geologist; and no one, I think, can study the ges of his "Recherches" without admitting that he himself possses these qualifications in an eminent degree.

He has also reminded us, or rather takes for granted that we member what some of us seem apt to forget, that lithological aracters alone form untrustworthy foundation for rock-groups, at the same stage or formation can be a clay in one district and marl or sandstone in another, that Gault may include sand as ell as clay, and that this is particularly the case with the Upper ault or zone of *Ammonites inflatus*.

Working on these data he has determined the existence of a succeson of palæontological zones from the Gault upwards throughout the halk, and carefully followed them over the Cretaceous areas of the ritish Isles.

The first four of these zones are as follows:—

1. Zone of *Amm. inflatus* = Blackdown Beds.
2. „ *Pecten asper* = Warminster Beds.
3. Chloritic Marl.
4. Zone of *Holaster subglobosus* = Chalk Marl.

Regarding the first two of these divisions, he says (p. 71), "The pper Greensand, as defined by Berger, Inglefield, Webster, Fitton, d Ibbetson, appears to me everywhere divisible into two zones; e zone of *Am. inflatus*, and the zone of *P. asper*. The fauna of e Upper Greensand, being a mixture of these two faunas, had of ecessity relations with both." Again at p. 105, "I had thought at the lithological characters of the Upper Greensand would make a special division, distinct from the other horizons; but I was eceived, and in the Upper Greensand of the Isle of Wight, as in at of the rest of England, there are two perfectly distinct faunas, at of Blackdown and that of Warminster." The case, however, is ot quite so simple as would appear from this, for the lower and ayey portions of the *Amm. inflatus* zone have always been exuded from the Upper Greensand; the two zones therefore do ot exactly form its equivalent, since they include more than the pper Greensand.

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[1] Recherches sur le Terrain Crétacé supérieur de l'Angleterre et de l'Ireland, par . Barrois, D.Sc. Lille, 1876.

I will now give Dr. Barrois' interpretations of the sections in the three areas we have been chiefly concerned with, viz. the Weald, the Isle of Wight, and the Western area. In the Isle of Wight, at St. Lawrence, he gives the following:—

Zone I. *Amm. inflatus.*	Feet
A. Micaceous and Glauconitic sands, with bluish argillaceous bands at the bottom	105
B. Yellowish sandstone, with hard siliceous bands	12
Zone II. *Pecten asper.*	
C. Greensand with phosphate nodules	6
D. Bands of green sandstone and bluish chert	24
E. Chloritic Marl	7

A certain similarity will be noticed between this section and those previously given, all of them being capable of a natural division into two unequal portions, to the upper of which all unite in giving a thickness of 30 to 36 feet. Moreover, the lists given by Dr. Barrois from these two divisions, in the Isle of Wight and the neighbouring county of Dorset, show that they contain two different groups of fossils, the one of which corresponds with that found in the Upper Gault and Blackdown beds, while the other resembles the Warminster fauna. In Surrey (p. 141), he looks upon the lower soft sandstones and marls as belonging to the zone of *Am. inflatus*, and upon the Firestone as representing the zone of *P. asper*. In Hampshire he gives an account of the beds near Petersfield (p. 36), and thus describes them—

	Feet
1. Soft, micaceous sandy beds, with *Am. inflatus*	75
2. Coarse quartzose sands and sandstones	15
3. Marly bed with glauconite and nodules of phosphate of lime (no fossils seen)	3

The second he refers to the Warminster beds or *Pecten asper* zone, and the last he assimilates to the Chloritic Marl; remarking "that these two horizons have not before been identified in this part of Hampshire." He also mentions a road section near Binstead, where a similar nodule bed is seen resting on coarse greensands, which he considers to represent the *Pecten asper* zone; he does not give any very definite opinion regarding the position of the Malm-rock, but he does not seem to distinguish it from Firestone.

The superposition of the Warminster beds to those of the Blackdown or *Amm. inflatus* zone is stated to be visible in the vales of Warminster and Pewsey, even if it had not been so clearly indicated by Mr. Meyer in Devonshire.

He adopts Mr. Meyer's account of the series of beds exhibited near Beer Head as giving an accurate description of the different horizons, but differs from him in the correlation of the several groups; admitting the existence of a Blackdown fauna (belonging to Etage A) in the beds numbered 2 and 3, he does not think that Nos. 4, 5 and 6 are sufficiently different to be separated from the lower beds, and as they contain large *Pecten 4-costatus* and *Ex. conica,* he refers them to Etage B of the same division or zone (see ante). No. 7 he considers to be a pebble bed separating the two divisions, and he gives to the lower or *Am. inflatus* zone a thickness of 75 ft. Nos. 8 and 9 he parallels with his Etage C, and numbers 10, 11, 12 he agrees with Mr. Meyer in referring to the fossiliferous portion of the Warminster beds; thus giving to the whole zone of *P. asper* a thickness of 21 feet. Nos. 13 and 14, called Chalk Marl by Mr. Meyer, he correlates with the Chloritic Marl, though admitting the possibility of the latter bed being the attenuated representative of his *Holaster subglobosus* zone or Chalk Marl.

He proceeds to trace these several stages through Devon and Dorset, but we must not forget that Mr. De Rance had accurately described them in 1874, and had even given the same names to two of the groups; had he indeed ventured on a more extended correlation of the zones, he would perhaps have anticipated Dr. Barrois' division of the Upper Greensand; referring to the tables before given, it is evident that zone I. of De Rance = Etage E (Chloritic Marl), that zone II. = Etages D and E (*Pecten asper*), zone III. = Etage B (*Ex. conica*), while the Fox-mould and Cowstones represent Etage A of the *Am. inflatus* zone.

The section on the northern side of Swanage Bay has also been recently described by Mr. H. G. Fordham,[1] who divides the Upper Greensand into its local component beds; he informs me that he would assimilate the first three of these, with a total thickness of 26 feet, to the *P. asper* zone, and refer the remaining 40 or 50 feet to the *Am. inflatus* zone of Dr. Barrois.

Regarding the Chloritic Marl he says that its junction with the underlying Upper Greensand is irregular but well marked, and further on, "I have used the term Chloritic Marl to signify the lowest bed of the Chalk Marl, which is characterized by the presence of glauconitic grains, and a Chalk Marl fauna, mixed with many derived phosphatic casts of fossils." Its thickness he gives as 4 feet, and correlates it with the Cambridge phosphate bed and No. 13 of Mr. Meyer's section.

Concluding Remarks.—As I conceive we now possess a knowledge of the true order and succession of the Greensand beds above the Gault, together with a more accurate conception of their character, contents, and extent, it only remains for me to make a few remarks on the application of the terms Chloritic Marl and Upper Greensand, and to indicate one or two points that seem to require still further investigation.

From the foregoing sectional evidence I think it is clear that no break occurs in the series from the base of the Gault upwards till we reach the so-called Chloritic Marl, and that here there is a well-marked discontinuity, both stratigraphical and palæontological. The line of separation and slight erosion at its base in the south-west becomes more decided when traced to the north-east, and the small indigenous fauna, when the numerous derived fossils are separated from it, is found to differ very little from that of the Chalk-marl. and to be quite distinct from that of the *Pecten asper* zone. In the Wealden area the line of division appears to be less clear, there has been less erosion, and the bed contains fewer fossils either indigenous or derivative; it has on this account been generally confused with the sands below, and the two together have been called Chloritic Marl. Dr. Barrois, however, has shown that it is divisible from these sands in Hampshire, and it seems probable that the latter are lenticular beds belonging to the *P. asper* zone sometimes attaining a thickness of 10 or 15 feet and sometimes thinning out altogether, while the thin bed of sandy marl with glauconitic and phosphate nodules has a wider extent, and is probably to be found at the base of the Chalk-marl all round the Weald; its existence is very marked in the neighbourhood of Maidstone, where it directly overlies the Gault, as at Cambridge, without the interposition of any Upper Greensand strata whatever.

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[1] Proc. Geol. Assoc. vol. iv. p. 8.

The thickness of this bed is rarely more than 3 or 4 feet, but it passes gradually upwards into the Chalk-marl from which it is inseparable, except so far as its green grains and phosphate nodules give it a character of its own. Thus it is clear that the narrow zone of glauconitic marl lying at the base of the Chalk cannot be considered as forming a separate division, and therefore does not merit such a name as that of Chloritic Marl, which at once suggests a comparison with the Chalk-marl, and gives it an importance far greater than it possesses; moreover, it has often been pointed out that the name itself is based on a misconception, in as much as the green grains are not composed of *Chlorite* but *Glauconite*, and I therefore agree with Mr. Whitaker and Mr. Price in advocating the entire abandonment of the name.

Since, however, the bed itself does exist as a zone subordinate to the Chalk Marl, it is desirable that some name indicative of this should be assigned to it; Mr. Davidson and Mr. De Rance have called it the zone of *Scaphites æqualis*, and perhaps that name can be adopted; at the same time it may be observed that this fossil is both of wide and partial distribution; it is known to occur both in the beds above and below, while in some areas, as at Cambridge, it does not seem to exist in the zone of which it is supposed to be characteristic. It may therefore be found more convenient to indicate this horizon by one of the numerous sponges, which it everywhere contains, and which are now being described by my friend Mr. W. J. Sollas. Or, lastly, it may have to be amalgamated with the horizon immediately succeeding it, which Dr. Barrois calls the zone of *Plocoscyphia mæandroides*, further information being required concerning the persistence of this band and its relation to the marl below.

Finally, it is desirable that some more clear definition of the Upper Greensand should be given. I remember Prof. Ramsay once observing that Gault and Greensand were the same thing, and doubtless they are in the sense that no hard and fast stratigraphical line can be drawn between them, but taken as a whole it is found that the series can be divided into three groups of beds, each containing a peculiar fauna of its own, and worthy of a separate name.

Dr. Barrois says that the English Upper Greensand consists of two parts, which he calls the zones of *Am. inflatus* and *Pecten asper*, but

› is not strictly true, because the former zone contains beds of ılt Clay which have never been included in the Upper Greensand. › real fact is, that recent researches have shown the formations ›wn as Gault and Upper Greensand each to consist of two isions, but the lower part of the one being united palæontoically with the upper member of the other, only three wellrked groups can be established. Supposing, therefore, that the nes of Gault and Upper Greensand are still retained, we must ide to which of the two this intermediate zone more probably ongs, whether in fact we should extend the Greensand downrd or the Gault upward. I would advocate the latter measure, l the restriction of the term Upper Greensand to the group of .s containing a Warminster fauna; with regard to stage B, taining *Ex. conica* (the Upper Greensand of Mr. Meyer), I do think Dr. Barrois gives very strong reasons for classing it in lower division; it is true that it does not contain many fossils, l that these do not indicate any marked affinities, but the large ıira *æquicostata* is I think mostly found in the Warminster :s; its lithological constitution certainly links it rather with upper than the lower beds. I would suggest, therefore, that zone B of *Ex. conica* be included with the Warminster beds, l that the limit of the lower division be placed at the shingle ls in No. 4 of Mr. Meyer's section. The upper division would n consist of two parts, zone of *Pecten asper* and zone of *Ex. ica*, De Rance, the lower of which may be taken as forming the e of the Upper Greensand. As a matter of fact this bed has 'ays been included in that formation, and it would cause great fusion if in retaining the term we excluded this part of it; the ›fold constitution of the Greensand is well seen at Wantage, ere, according to Mr. E. C. Davey, 30 feet of soft greensands are lerlaid by 6 feet of firestone.

GENERAL CLASSIFICATION.

		Feet
lk Marl	*c* Marl with small Brachiopods *b* Zone of *Plocos. mæandroides* *a* Glauconite (Chloritic) Marl	40—80
›er Greensand	Warminster beds = zones of *P. asper* and *Ex. conica* (De Rance)	35—45
›er Gault	Blackdown beds or zone of *Ammonites inflatus*	60—100
'er Gault	Albien of D'Orbigny = zones of *Am. lautus* and *Am. interruptus*	30—150
'er Greensand	Aptien of D'Orbigny = zones of *Am. mammillaris* and Folkestone beds.	?—100

[he arrangement above suggested has also the merit of necessitaȝ only a very slight alteration in the lines on the published vey Maps, the term is rendered lithologically applicable, and a .nite fauna is secured to the formation instead of a mixture of › different groups. It is true that the lists of Upper Greensand ıils will have to be revised, and those excluded which belong to lower zone; but that was requisite in any case, and I venture to ›e that in the future care will be taken to indicate the exact ılity and horizon where any particular fossil or fossils are found.

I conclude with appending a table in which the various local beds are correlated as far as possible with one another. I would point out that the horizon of the Malm-rock is somewhat uncertain, but that its fauna appears to belong to that of the *P. asper* zone; also that I have included Etage B, and beds 5 and 6 of the Devon section, in the same division, thus giving to it a thickness of from 35 to 45 feet.

While thus endeavouring to limit satisfactorily the three stages into which the Gault and Greensand can be divided, and which it is important to recognize, it must be remembered that they really pass into one another and form a continuous series; so that it is impossible to draw very definite lines between them such as that which does exist above the *P. asper* zone and divides it from the overlying Chalk-marl.

Comparative Sections.

s.	Folkestone (Price)	Merstham (Barrois)	Selbourne (Geol. Sur.)	I. of Wight (Barrois)	Devon (Meyer)	Wiltshire (Barrois)	Camb
	Clayey marls	Chalk Marl	Chalk Marl	Marl with *Turrilites*	(Absent.)	Marl with *Rh. Martini*	Marl w Brachi
o- *ia* *nides*	Qy. of *Ploc. mæandroides*	?	?	Qy. of *Ploc. mæandroides*	(Absent)	?	Absent
aphites ? *equalis*	Zone of *Stauronema*	?	Chloritic Marl	Chloritic Marl	No. 13.	Chloritic Marl	Camb Greens
Pecten *asper*	Absent ?	Upper sands & Firestone	Upper sands and Malm Rock	Sandstones D. C. & B.	5 to 12 Warminster beds.	Warminster beds	Absent
Ammon. *nflatus*	Sandy and marly clays	Lower sands and marls	Sandy marls	Sands and Sandy-clays = A.	2 to 4 Blackdown fauna	Micaceous sands and clays	Absent base of
Ammon. *lautus*	Gault clays	Gault	Gault (part)	Black clay.	Black clay	Dark clay	Gault

NOTICES OF MEMOIRS.

I.—Professor Owen's Fossil Mammals of Australia.

In pursuance of his aim to leave records of the vertebrate fossils of our Colonies, Prof. Owen, after the issue of his "Catalogue of the Fossil Reptilia of South Africa" (4to. 1876), proceeded to prepare for press his notes "On the Fossil Mammals of Australia," portions of which have from time to time appeared in the "Philosophical Transactions." To the materials systematically arranged in the work now issued he has premised a chapter on the Fossil Marsupials of Great Britain, the whole being included in two quarto volumes, one of text (pp. 522, with interspersed woodcuts); the other of plates, 132 in number, under the title "Researches on the Fossil Remains of the Extinct Mammals of Australia." The aim of this work is, mainly, to afford the Australian students of Palæontology a ready means of comparison of the mammalian fossils which may come under their observation; and for this purpose illustrations of the osteology and dentition of existing Marsupials are given, more especially of species of the families of the Kangaroos (*Macropodidæ*) and Wombats (*Phascolomyidæ*).

Of the genus *Diprotodon*, indicated, in 1835, by a fragment of lower jaw with an incisor of a young individual, fossil evidences since received, and described in this work, have enabled the author to give a restoration of the skeleton of the largest species (*D. australis*). Of the genus *Nototherium* much of the skeleton is restored and three species defined—*N. Mitchellii*, *N. Victoriæ*, and *N. inerme*.

An extinct genus (*Phascolonus*), of the Wombat family, is founded on fossils indicative of a species which attained the bulk of a Tapir; and evidences of five extinct species of *Phascolomys* are adduced from fossils more nearly the size of the existing Wombat. In addition to larger species of the existing genus *Macropus*, e.g. *Macr. Titan*, the author adduces characters of the dentition and limbs referable to seven extinct genera of the Kangaroo family.

II.—NOTE PRÉLIMINAIRE SUR LE TERRAIN SILURIEN DE L'OUEST DE LA BRETAGNE. Par Dr. CHAS. BARROIS. (Ann. de la Soc. Géol. du Nord, vol. iv. p. 38.)

IN this paper the author pursues a similar course with regard to the Silurian, to that which he took a short time since with the Devonian deposits of this district.[1]

The stratified deposits in this locality rest on the Gneiss of Brest, and are divided by the central granite plateau of Brittany into two great masses, a northern and a southern, each of which is again subdivided into eastern and western basins, and it is the Silurian beds in the western basin of the southern mass—the Finisterre basin—that are here treated of. They consist of a series of schists, sandstones and quartzites, and may be tabulated as follows, commencing with the Gneiss de Brest, then follow in ascending order:—Mica-schists; Phyllades vertes de Douarnenez; Poudingues et Schistes rouge lie-de-vin du Cap la Chèvre; Grès blancs des Montagnes Noires à *Scolitus linearis*; Schistes de Morgat à *Calymene Tristani*, the most fossiliferous division of the group; Schistes et Quartzites de Plougastel. The last named have been classed by some previous observers as Devonian; but are considered by M. Barrois to be of Silurian age, and the equivalents of the "Grès blancs sans fossiles" of Dalimier in the Rennes and Cotentin basins.

M. Barrois maintains that these Silurian beds of the Finisterre basin exhibit precisely the same divisions as in the better studied regions of the province; the modern ideas of their true stratigraphy being founded on misconceptions as to the real age of the schists and quartzites of Plougastel, whilst a large fault running down the valley of the river Elorn and the estuary of Brest has been entirely overlooked.—B. B. W.

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[1] Ann. de la Soc. Géol. du Nord, vol. iv. p. 59; GEOL. MAG. June, 1877, p. 280.

III.—NATURAL HISTORY TRANSACTIONS OF NORTHUMBERLAND AND DURHAM. Vol. V. Part III. (London: Messrs. Williams and Norgate.)

THIS number contains two palæontological papers of interest. The first, "On the Skull and other Bones of *Loxomma Allmanni*, Hux., from the Low Main, Newsham, Northumberland," by Messrs. Dennis, Embleton, and T. Atthey, contains a most careful and minute description of the most complete specimen of the skull of this reptile yet found, the upper surface and border being perfect. Close by it were found the two halves, right and left, of a lower jaw, fitting it, and probably belonging to the same individual, as well as some vertebræ, ribs and other bones. When viewed from above, the skull has a general resemblance to that of *Archegosaurus* and the Crocodilia, and of the latter, the Alligator rather than the Crocodile. The teeth are nearly all broken off transversely, and exhibit a beautiful labyrinthodontine structure, which is well figured on pl. iv. Its affinities with the fishes are shown by the existence of one concave articular surface instead of a condyle or condyles, and by the existence of two facets on the exoccipitals for articulation with the neural arch of the atlas; whilst the form, size, and solidarity of the skull, together with its peculiarly reticulated surface, resembles that of the Alligator. Its zoological position is defined as being between the Salamandroid fishes and the Crocodilia.

The second paper contains an equally elaborate description, by Mr. T. Atthey, of the largest by far of the three Labyrinthodonts yet found in the Northumberland Coal-field—*Anthracosaurus Russelli*, Hux. The parts treated of are the upper and under surface of the skull, both rami of the mandible, the teeth scutes and other bones.

The plates illustrating these two papers are admirably executed.—
B. B. W.

REVIEWS.

I.—THE LAKE DWELLINGS OF SWITZERLAND AND OTHER PARTS OF EUROPE. By Dr. FERDINAND KELLER. Translated and arranged by JOHN EDWARD LEE, F.S.A., F.G.S., etc. Forthcoming second edition. (London, Longmans, Green & Co.)

(PLATE XI.)

STUDENTS of Prehistoric Archæology in this country are largely indebted to Mr. John Edward Lee, of Torquay, for the valuable service he has rendered them in presenting to English readers so excellent a version of Dr. Ferdinand Keller's great work on the Lake-Dwellings of Switzerland, noticed by us in the GEOLOGICAL MAGAZINE for 1866, Vol. III. p. 460.

So thoroughly has Mr. Lee's labour been appreciated, that a new edition has been called for, and is actually completed, and will shortly appear.

In the eleven years that have intervened since the appearance of the first edition, the Swiss antiquaries have largely added to their fund of information concerning these lacustrine habitations, the peoples that inhabited them, their domesticated animals, the beasts of the chase which they hunted, their weapons, and the rude arts and manufactures which they practised. Other sources of information have also been largely drawn upon in order to show that lake-dwellings existed in other parts of Europe, and also in Ireland, Scotland, and Wales, which in many respects may be considered analogous to certain peculiar constructions found in Switzerland, although of later date. The translator has contributed liberally from his own stores of antiquarian lore towards the interpretation of innumerable points of interest bearing upon the fabrication and uses of the thousand and one objects which have been dug or dredged up from amid the pile-works of these truly wonderful *Pfahlbauten.*

The new edition is *largely increased* as regards the number of its illustrations, as well as in the subject-matter contained in the text itself.

The book is far removed from a mere translation. On nearly every page Mr. Lee has added some fresh piece of information, collected from innumerable sources, which tends greatly to enhance the value and usefulness of the work.

By the courtesy of Mr. Lee, we are permitted to reproduce a most interesting and remarkable view of the stumps of the piles which once supported the Lake-dwelling of Möringen, a settlement of the Bronze age on the shores of the Lake of Bienne, which conveys at a glance a wonderful idea of the extent of one of these settlements and the labour involved in its erection. We hope soon to have the new edition before us, and will not therefore now say more as to its increased usefulness, but will reserve the description of Möringen and other points of interest for a later notice.

II.—THE "TESTIMONY OF THE ROCKS" IN NORFOLK. A Popular Description of the Geology of the County. By F. W. HARMER, F G.S. pp. 38. (London: Hamilton, Adams, and Co.)

THIS sketch of the geology of Norfolk was delivered as a lecture at Norwich in March, 1877, and gives in an easy and interesting form an account of the great physical changes which the area has undergone since Cretaceous times. The method of formation of the Chalk, the Norwich Crag, the Forest-Bed, and the Glacial deposits are especially dwelt upon. Accompanying this little work is an excellent coloured geological section from Hunstanton Cliff to Great Yarmouth, on which the relations of the various strata are well shown, while the beds passed through in the deep wells at Norwich and Yarmouth are particularly noticed. The "Carstone" of Hunstanton, of Lower Greensand age, is grouped as Neocomian, under the local name of "Sandringham Beds." These beds are stated to consist of sand with shingle-beds in their upper part in the extreme north-west of Norfolk, and which, where indurated, are called Carstone. We can heartily recommend Mr. Harmer's lecture to those who wish to grasp the main features of the geology of Norfolk without entering into the details.

REPORTS AND PROCEEDINGS.

I.—Cotswold Field Club. —The 32nd anniversary meeting of Cotswold Club, under the presidency of Sir W. V. Guise, Ba F.L.S., etc., took place on April 14, 1877. It was also the 1 annual meeting presided over by its president. About thi members attended to hear the address and to arrange for meetings and general business of the coming season. The club th adjourned to the School of Art to hear Mr. W. C. Lucy's paper on "T Extension of the Boulder-clay and Drift over the Cotswold Rang

Mr. Lucy referred to a former paper read before the Club in 18 in which he stated that he had not found Northern Drift pebbles a higher elevation than 750 feet, confirming the observations ma many years ago by Prof. Hull, when surveying the district. Lucy also mentioned that he was not aware of the presence Boulder-clay, unless some clay which had been found in the partin of a quarry at Woodchester, with a small quantity of pebbles i bedded in it, should prove to be it. The special object of his pa seemed to be the discovery of the same highly silicified clay various parts of the Cotswolds, *including the highest point of Cle Cloud.* This clay he had had analyzed by Prof. Church and Embrey, and the result, as will be seen by the following table, show so marked a resemblance in the per-centage of silica as to lea no doubt that it was all derived from the same source; and fr the Northern Drift pebbles being found with it, Mr. Lucy classed as belonging to the Boulder-clay period, indicating that the wh of the Cotswold range was submerged during that time. Mr. Lu also traced the same clay in a gravel-pit in the vale at Frampto which clay he believed was once on the higher ground, and fr the weathering of the friable Oolitic rocks, had been brought in its present position.

	Woodchester Park.	Cleeve Cloud.	Symonds Hall Farm.	Painswick Hill.	Frampton Gravel Pit.
Silica ...	70·50	67·2	69·58	68·2	69·60

Mr. Lucy further pointed out the undoubted presence of ice actio as shown at Limbury, and at Aston Magna, and other parts of t Upper Cotswolds, and explained that striations were not found the Gloucester area owing to the soft character of the Oolitic rock We cannot follow him in the account he gave of the grooving of t Lias in the valleys upon which some of the gravels rest, nor t very difficult and complicated second Boulder-clay to which referred.

II.—Geological Society of London.—June 20, 1877.—Pr P. Martin Duncan, M.B., F.R.S., President, in the Chair.

The following papers were read:

1. "On a Hitherto Unnoticed Circumstance Affecting the Pilin up of Volcanic Cones." By R. Mallet, Esq., F.R.S., F.G.S.

After some remarks upon the two forms of volcanic activity, earlier system of "fissure eruption," and the present one of "erupti at explosive foci," which he did not think could be carried back much beyond the Tertiary epoch, the author discussed the ordinary method of formation of a volcanic cone, and pointed out that the effect of the piling up of material must produce a pressure on the original surface commensurate with the amount of material heaped up on it, and therefore increasing gradually from the circumference nearly to the centre of the cone, where the loftiest column of material presses upon the unit of space. When the supporting rock is unyielding, such as the granite which bears the Puys of Auvergne, it will probably maintain its original position; but when it is of a more yielding nature, as in the case of the ordinary stratified rocks, the pressure of the cone will produce a saucer-shaped depression, deepest in the centre where the greatest pressure occurs; and this tendency to sink will be aided materially by the honeycombing and evisceration of the subjacent rock-masses exposed to the action of the volcano. The consequence of this depression of the surface supporting the cone will be to diminish the original slope of the successive superimposed deposits, and even in some cases cause the lowest beds to slope from the circumference towards the centre. If the strata upon which the volcano stands be particularly plastic, its pressure may cause an uprise of the strata into protuberances round the foot of the mountain. Similar phenomena may occur when the support of the cone is formed by older volcanic deposits.

2. "The Steppes of Southern Russia." By Thomas Belt, Esq., F.G.S.

The author describes sections of strata in the south of Russia, and traces the following succession of events:

1. Deposition of marine Miocene beds when the Vienna basin and the Aralo-Caspian area were joined together, and had free communication with the Mediterranean.
2. Interruption of the communication with the Mediterranean, and deposition of the Sarmatic beds in a closed sea-basin.
3. Gradual freshening of the water of this area and deposition of the Congerian strata.
4. Lowering of the water of the Vienna basin and Aralo-Caspian area to below the present level of the ocean, and great denudation of the preceding strata. The author thinks that the drainage was at this time to the north.
5. Interruption of drainage to the north and deposition of fluviatile beds, with freshwater shells of existing species and remains of the Mammoth and Irish Elk.
6. Drainage to the north completely stopped and formation of a great lake, over which floated icebergs with northern drift. Formation of diluvial clay of the south and boulder-clays of the north of Russia.
7. Lake gradually lowered by the cutting through of the channel of the Bosphorus.

The author considers that the formation of the great lake was due to the ice of the glacial period flowing down the beds of the Atlantic and Pacific, and damming back the drainage of the continents as far as it extended. To the rising of these waters he ascribes the destruction of palæolithic man, the mammoth, and the woolly rhinoceros, which he considers are prediluvial. This lake was once suddenly and torrentially discharged through the breaking away of the Atlantic ice-dam, causing the outspread of the middle glacial sands and gravels, but was formed again, and ultimately drained by the cutting through of the channel of the Bosphorus.

He also offers suggestions to account for the preservation of the Aralo-Caspian fauna and the arrival of Arctic animals in the area.

3. "The Glacial Period." By J. F. Campbell, Esq., F.G.S.

In this paper the author gave the results of numerous observations extending over many years, and made in many different parts of the world, the results of which had led him to form the opinion that no geological record exists of any abnormal Glacial periods colder than the present world's climate. But if the term "Glacial period" be used with a limitation, such as "local," or "Alpine," or "European," he saw nothing to object to. Changes in the relations between the surface of the earth and the undoubtedly permanently glacial portions of the atmosphere, principally brought about by changes of level in the former, appeared to him sufficient to account for the phenomena. The most recent so-called Glacial periods being fixed in Postpliocene times, the author remarked that Indian glaciers (lat. 27°–32° N.) are now almost as large as they have been since the deposition of the crumpled Tertiary deposits known as "Nahuns" and "Sivaliks." A similar result was obtained from observations in the Caucasus (lat. 40° N.) and Rocky Mountains (lat. 36°–37° N.). In Northern Italy (about lat. 45°–46° N.) glaciers were a great deal larger in Postpliocene times than at present.

Phillipsite or lime Harmotome also occurs, associated with the preceding, just as in the amygdaloidal trap of Iceland. In hollows of the calcareous cement small crystals of apophyllite occur, with pulverulent and minutely-crystalline fluor spar, together with other minerals not identified, but resembling in character gismondine and scolezite. At Plombières hyalite occurs with the zeolites; and where the masonry is exposed to the full flow of the water there is a transparent gelatinous deposit, which becomes white and opaque when dry, and is a hydrated silicate of lime analogous to okenite. Aragonite occurs generally in acicular crystals, but sometimes of the form called apotome by Haüy, found in iron ore deposits and in some basalts. Calcite is frequently associated with the chabasite, as in Icelandic lavas. Halloysite is also met with at Plombières.

Besides the formation of geodes in the visible cavities, the whole substance of the bricks was found to be altered by contact with the water. This change rendered the originally friable brick very hard and compact; and microscopic examination showed that its minute pores were filled with colourless and transparent mineral substances. The author gave the following list of the minerals thus found:—Chabasite, christianite (?), mesotype, hyalite (?), tridymite, chalcedony in radiate spherules, calcite, and some globular bodies of uncertain nature. The association of chalcedonic quartz with opal is interesting, as proving that silica may be deposited in the anhydrous form when the temperature of the surrounding medium does not exceed 70° C. Analysis showed that the amount of zeolitic substance added to the bricks is from 13 to 14 per cent. of the total weight.

This contemporary production of zeolites and other minerals identical with those found in amygdaloidal and many other altered volcanic rocks is regarded by the author as an experimental demonstration of the mode of formation of the latter, which are no doubt produced in a similar manner by the percolation of water through the substance of the rocks, conveying to, and depositing in, their cavities mineral substances, dissolved during its passage. Zeolitic minerals, as he says, may therefore be considered a kind of "extract" of the rocks so subjected to continued lixiviation. And the process being effected independently of any peculiar conditions of heat and pressure, would seem to show that no such conditions are essential in the production of natural zeolites.

6. "On the Cretaceous Dentaliadæ." By J. S. Gardner, Esq., F.G.S.

In this paper the author described the Dentaliadæ from the British Cretaceous rocks, of which he enumerated the following species:—*Dentalium decussatum*, Sow., and var. *ellipticum*, Sow. (Gault); *D. medium*, Sow. (Gault, Greensand, and Grey Chalk); *D. divisiensis*, sp. n. (Upper Greensand); *D. alatum*, sp. n. (Gault); *D. cylindricum*, Sow. (Blackdown); *D, acuminatum*, sp. n. (Gault); *D. subtetragonum*, sp. n. (Gault); *D. tetragonum*, sp. n. (Gault); *Entalis Meyeri*, sp. n. (Blackdown); and *Gadus gaultinus*, sp. n. (Gault).

7. "On a number of New Sections around the Estuary of the Dee which exhibit Phenomena having an Important Bearing on the

[illegible] Boulder-clay and the Sequence of Glacial Events." By D. [illegible], Esq., F.G.S.

In this paper the author minutely stated the results of repeated examinations of a number of new sections of drift-deposits, with a particular reference to the character of their bases and lines of junction between them. He described in detail the patterns exhibited by the grooved erratic stones of the shelly clays compared with irregularly scratched stones of the Lake District. He then gave a particular account of the character of the two shelly clays, and assigned reasons for believing in their threefold origin—the local grit and broken shells accumulated by the sea, which at the time was fully charged with sub-glacial clay, and the erratic stones carried and dropped by floating coast-ice. He described phenomena proving that boulders must have *fallen* into the clay, and called attention to the varying directions of striæ on rock-surfaces (including some he had lately discovered), and their relations to the courses and cross-courses taken by erratic stones, some of which had travelled 200 miles. He then connected the special observations he had lately made with the results of many years' investigations extending around the basin of the Irish Sea, from Carlisle to Crewe, and from Crewe to Anglesey, and traced the horizontal and vertical extent of the three shelly drifts, and their relation to the mountain drifts of North Wales and the Lake District. He stated many reasons for rejecting the idea that land-ice had distributed either of the two Boulder-clays he had described, but left it an open question whether the blue clay of North Wales, the Lake District, the Yorkshire valleys, and parts of Lancashire, with its local stones, may not have been accumulated under land-ice. He concluded by stating that the paper was intended to be introductory to one on the correlation of the drifts of the north-west with those of the eastern and central parts of England.

8. "Discovery of Silurian Beds in Teesdale." By W. Gunn, Esq., F.G.S., and C. T. Clough, Esq., B.A., F.G.S., of H.M. Geological Survey.

The authors described the general physical characters of Teesdale, referring especially to the position of the Burstreeford Dyke, the whin, according to them, occupying a very different horizon at Forcegarth Hill and Cronkley Fell, so that the displacement indicated by it is probably 400 feet greater than has been supposed. This disturbance has brought up the beds which lie at the base of the Carboniferous series in the dale, and these are exposed in the banks of the Tees at the old Pencil Mill at Cronkley, where they were formerly worked up into slate pencils. They are soft shales, usually gray or greenish gray, sometimes yellowish green or purplish red. They are very indistinctly bedded, but show traces of what may be cleavage in some parts. From the character of the deposit, the character of the dykes of the district, and the fact that these beds are not altered by them, the character of the veins traversing them, and an apparent unconformity between these beds and the undoubtedly Carboniferous beds overlying them, the authors come [illegible] conclusion that this deposit is not of Carboniferous, but of

Silurian age, and they indicate certain theoretical conclusions which follow from this determination.

9. "On the Superficial Geology of British Columbia." By George Mercer Dawson, Esq., F.G.S., Assoc. R.S.M., of the Geological Survey of Canada.

The author stated that the rock-striation and fluting on the south-eastern peninsula of Vancouver's Island shows that at one time a great glacier swept over it from N. to S., filling the Strait of Georgia, 50 miles broad in places, and having near Victoria a thickness of ice of over 600 feet. Traces of this glacier also occur on San Juan Island, and on the coast of the mainland. The deposits immediately overlying the glaciated rocks, besides what may be *moraine profonde*, locally developed, are sandy clays and sands, arranged in water, and sometimes containing marine shells. The lower beds, at least, of these, were probably formed at the foot of the retreating glacier, the sea standing considerably higher than at present. The northern part of the Strait of Georgia and the fjords opening into it, and the fjords north of the Strait, show ice-action to a height of above 3000 feet. Terraces on the coast of the mainland are rare, and never at great elevations.

The interior plateau of British Columbia shows a system of glaciation from N. to S., traces of which have been observed above 3000 feet. Subsequent glaciation radiating from the mountains also occurs. The superficial deposits here are either unmodified or modified. The former, representing the Boulder-clay, occurs at nearly all heights up to over 5000 feet; the latter characterizes nearly all localities below 3000 feet, and is most extensively developed in the northern low country, where it forms a white silt or loess. The interior is marked with shore-lines and terraces up to 5270 feet. Moraines occur in great numbers, most of them marking stages in the retreat of glaciers towards the mountains, although some may have been formed in connexion with the N. and S. glaciation.

The sequence of events in the interior, according to the author, seems to have been as follows:—Glaciation from N. to S., with deposit of Boulder-clay; formation of terraces by lowering of water surfaces, accompanied or followed by a warm period; advance of glaciers from the mountains, and formation of lower terraces; and retreat of glaciers to their present limits. The glaciation of Vancouver's Island may have occurred during both cold periods or during the second only.

The author considers the assumption of the production of the N. to S. glaciation by an ice-cap to be attended with great difficulties, and seems to favour the notion of its being effected by the accumulation of ice on the country itself, and especially on the mountains to the N., filling the central plateau in going southward, and passing seaward through the gaps and fjords of the coast range.

10. "The Exploration of the Ossiferous Deposit at Windy Knoll, Castleton, Derbyshire, by Rooke Pennington, Esq., LL.B., F.G.S., and Prof. W. Boyd Dawkins." By Prof. W. Boyd Dawkins, M.A., F.R.S., F.G.S.

In this paper the author gave an account of the results of a further exploration of the ossiferous deposit at Windy Knoll. The section exposed included the following beds in descending order:—Clayey débris without bones, probably quarry rubbish; yellow clay, with large blocks of limestone, etc., and containing bones of Bison, Reindeer, Hare, Wolf, Fox, and Bear; and stiff yellow loam resting on the surface of the limestone. The bones and teeth of animals were generally perfect, and had been buried in their natural positions. The entire skeleton of a Roedeer was found in the upper part of the yellow clay. As the work proceeded the limestone floor descended rapidly, and the ossiferous clay increased in thickness from 8 to 21 feet; at the bottom it rested on loose fragments of limestone, filling a vertical shaft. The author concluded that the rock-basin containing the ossiferous deposit was originally a swallow-hole, plenty of which occur in the immediate neighbourhood, and that the vertical shaft, filled with limestone fragments, probably led down into a cavern through which drainage took place. The rock-basin forming the mouth of the swallow-hole was lined with clay, as is not uncommon, and then converted into a pool, in which the ossiferous clay was accumulated. The author noticed the geographical changes which must have occurred in the district since the formation of the deposit, and indicated the proportions of the remains of young and old Bisons and Reindeer, which confirmed the conclusion arrived at in his former paper, that the Bisons were here in the summer and the Reindeer in the winter. He regarded the deposit as of late Pleistocene age.

11. "Description of the Fossil Organic Remains from Bendigo." By M. Carl August Zachariæ. Communicated by the President.

The author described the occurrence in the northern part of Nova Scotia of a great band of Silurian deposits, running nearly east and west, and traversed in a corresponding direction by numerous detached bands of granites, syenites, etc. Roughly parallel to the line of the latter there is a tolerably well-defined series of fractures running from Parrsboro on the Bay of Fundy to Guysboro on the Atlantic coast. The course of this line of disturbance is marked by metamorphism, and by the presence of associated ores of iron and copper. The principal localities where the latter occur are noticed by the author, who states that the copper deposits attain their greatest development near Lochaber Lake and Polson's Lake, where they form a series of veins, cutting at oblique angles black and red shales and quartzites, apparently of somewhat doubtful age. The quality of the ore is said to be good.

13. "Glacial Drift in the North-eastern Carpathians." By R. L. Jack, Esq., F.G.S., and John Horne, Esq., F.G.S., of the Geological Survey of Scotland.

In this paper the authors noticed the statements of previous observers as to the occurrence of glacial drift in the northern part of the Carpathian range, and described the rock-formations surrounding the head waters of the Theiss, and some drift sections observed in the valley of that river. They arrived at the following conclusions:—Glacial deposits are not abundantly developed in the valleys of the north-eastern Carpathian. The drift in the upper reaches of the Theiss is of the most fragmentary character, and is confined mainly to the broader portions of the valley. There is, however, sufficient evidence for maintaining that the Theiss valley was filled with a glacier upwards of 45 miles long, although the authors were unable to determine whether this glacier ever debouched on the plains of Hungary or ever reached the edge of the Carpathian chain; but they think it probable that such was the case.

14. "On Terminal Curvature in the South-western Counties." By W. A. E. Ussher, Esq., F.G.S., of H.M. Geological Survey.

The author discussed the views advocated by Mr. D. Mackintosh on the terminal curvature of slaty beds (Q. J. G. S. vol. xxiii. p. 326), and objected to the hypothesis that the phenomenon was produced by the action of ice in any form, which was the agency to which Mr. Mackintosh was most inclined to ascribe it. The author thought that what has been called terminal curvature might be produced by three distinct causes, namely,—1. The curvature produced by internal movements at great depths, afterwards rendered superficial by long subsequent denuding agencies; 2. The action of wedging frosts on the upturned edges of the beds as advocated by Mr. Godwin-Austen; and 3. The intrusion between the laminæ of the rocks of the roots and rootlets of growing trees.

15. "On the Chronological Classification of the Granitic Rocks of Ireland." By G. H. Kinahan, Esq., M.R.I.A. Communicated by Prof. Ramsay, F.R.S., F.G.S.

The author adopts Scheerer's definition that a *granite* is a rock of certain constitution, in which all the constituents are separately developed, and gives the name of *elvanites* to those granitic rocks in which part of the constituents are not perfectly crystallized. The elvanites pass into true granites on the one hand, and on the other into plutonic or volcanic rocks. They are thus "passage-rocks" between the two sections.

The author apparently regards all granites as formed by the metamorphosis either of the sedimentary rocks in which they occur, or of the plutonic rocks associated with these. Even intrusive granites are the product of an extreme degree of metamorphosis. Of metamorphosis he distinguishes two kinds, namely:—*Metapepsis*, or regional metamorphosis, extending over larger or smaller areas, and due to aqueo-igneous action; and *Paroptesis*, or local metamorphosis, caused by heat generated at or near local igneous action or a protrusion or sheet of igneous rock.

The author then indicates the application of these principles to the classification of the granitic rocks of Ireland in the chronological order of the sedimentary deposits with which they are associated, and divides these rocks into eleven classes, corresponding to the Cambrian, Cambro-Silurian, Silurian, Carboniferous, Triassic, and Tertiary series, with five intermediate classes, the latter generally divided again into sub-classes. The granitic rocks of different districts in Ireland are then described in some detail, and referred to their places in the proposed chronological scheme.

16. "The Cambrian Rocks of South-East Ireland." By G. H. Kinahan, Esq., M.R.I.A. Communicated by Prof. Ramsay, F.R.S., F.G.S.

The author states that these rocks are greatly altered by metamorphic action. Quartz rock occurs in dykes and other masses among the Cambrian and Cambro-Silurian rocks, but chiefly among the former; it may be foliated and converted into quartzite by what the author calls metapepsis (see preceding paper).

Of the Cambro-Silurian rocks the base is seen only in two places, at Greenore and on the S.W. coast of Wexford. At the former it is a fine reddish conglomerate, lying on or against schists; at the latter a massive slate conglomerate. The rocks of this series in ascending order are:—1. Black carbonaceous shales and slates, or grey beds with subordinate beds of grit; 2. Green and grey grits, shales and slates; 3. The Ballymoney series of green, grey, black, and red grits, sandstones, slates and shales, with interstratified igneous rocks; 4. Red, purple, and green beds, usually more or less argillaceous.

The Cambrian formation generally consists of green, purple, or reddish grits, shales and slates, but here and there with grey or even black beds. The author describes the Cambrian rocks in the various areas in which they occur, namely, at

Howth, where they are but little altered in the N., becoming more altered towards the S.

Bray Head, generally unaltered, and containing many specimens of *Oldhamia*, and with massive dykes of quartz rock.

S.E. Wicklow, where the western boundary is doubtful. Near Carrick mountain and to the westward the rocks are much altered, and the author thinks that probably masses of Cambrian rocks were forced by disturbances into the Cambro-Silurians, and then the whole were metamorphosed together.

N.E. Wexford. The area commences on the east coast near Courtown Harbour, extends S. to and beyond Wexford, and then S.W. to the coast near Bannow Bay. The rocks are generally submetamorphic, with many large protrusions of quartz-rock, generally changed by metapepsis into quartzite. Rooney's Rocks, S. of Poulshore, consist of two protrusions of quartz-rock, between and N. of which are green and purplish Cambrian shales, in which *Oldhamia antiqua* has been found, as also in a green bed further south at Cahore. On the coast of Haggard and Bannow the Cambrian and Cambro-Silurian rocks are mixed up very irregularly by means of numerous faults. At Bannow *Oldhamia* is not uncommon. The most continuous sections are seen in this area in the valley of the river Slaney, where the rocks generally dip to the N. at angles of 10°–60° or 80°, and are going from N. to S.:—

	Feet
1. Massive grits with some shaly beds, underlain by more or less altered grits and shales; average dip 30°, giving a thickness of about......	3000
2. Schists with quartzites (metamorphosed grits), dip 50°; about.........	4000
3. Schists with masses of quartzite (altered quartz rock), dip 40°; about	4000
Total about....................	11,000

but the numerous faults under the numbers uncertain.

S.E. Wexford. The rocks are more or less metamorphosed, graduating from schist through gneiss into granite near Carnsore.

CORRESPONDENCE.

THE RED CLAY OF THE DEEP-SEA AND THE GAULT DEPOSITS.

Sir,—In the May number of the Monthly Microscopical Journal, a portion of the address to the Royal Society in November last has been printed, in which the President mentioned the endeavour of Mr. Sorby, to determine the nature of the Red Clays of the ocean-bottom, and stated that Mr. Sorby had informed him that many specimens of the Red Clay are so entirely analogous to what the Gault must originally have been, that those specimens might almost be looked upon as being as truly modern Gault as the *Globigerina*-ooze is modern Chalk. This opinion it appears is derived from the similarity of the Gault deposits to those of the Red Clays of the ocean-bottom; but this passage of the address as reported is somewhat obscure. We can hardly, however, suppose that it is intended to convey that the Gault was deposited under conditions at all similar to those in which the Red Clay is now being deposited, as the former, especially as shown in its earlier beds, was a littoral and shallow-water deposit. This is abundantly shown by the common occurrence of wood, twigs, and cones of Sequoia and Pinus, by turtles' eggs, and by its mollusca, many of which belong to genera now confined to shallow water. The Gault in all parts of Europe has been proved to have been deposited in a sinking area, its fossil fauna showing the change to deeper-water conditions. Near Folkestone the change to the deeper water of the Grey-chalk sea is very plain, and is seen to have been a gradual one. The discovery of these Red Clays is of exceeding interest, but it is misleading to speak of them as analogous to the Gault. J. S. GARDNER.

PARK HOUSE, ST. JOHN'S WOOD PARK, N.W.
May 17*th*, 1877.

DR. WILLIAM SMITH'S GEOLOGICAL MAPS.

SIR,—At a recent sale the copper-plates of William Smith's original folio atlas of geologically coloured maps of England, sixteen in number, including the index, published in 1821, came into the possession of Mr. Edward Stanford, of Charing Cross, who is willing to sell them at, as he writes to me, a trifling cost (for sixteen large coppers), if purchased for the Geological Society. It would not pay now-a-days to reprint maps only of historical interest; but I venture to think that the maps of the father of English Geology are worthy of being preserved from the melting-pot, the doom of superannuated copper-plates, and entrusted to the safe keeping of some chartered society. I write this, therefore, to obtain the opinion of geologists on the matter, and shall be glad to receive the names of gentlemen who will subscribe for their purchase, as I propose, for presentation to the Geological Society, which already possesses the original manuscript maps. G. S. BOULGER, F.L.S., F.G.S.

SCIENTIFIC CLUB, 7, SAVILE ROW,
July 12, 1877.

PREMATURE CONCLUSIONS.

SIR,—The practice of the Geological Society, of publishing "abstracts" of papers read at the meetings, before the papers themselves are published, is sometimes of great service both to the authors and to the public; but it has this serious drawback, that the public generally found their conclusions regarding the value of the paper—and the correctness of the author's views—*not on the paper*, but on the "abstract," which necessarily contains but an imperfect statement of the data upon which the author has rested his arguments; and the probabilities are, that when the paper itself appears *in extenso* some months afterwards, the men who have based their conclusions upon the statements of the "abstract" will not care to make themselves acquainted with the details and arguments of the paper.

This drawback has come with great force to my mind (as no doubt it has done in the case of others) from the manner in which the paper I had the opportunity of bringing before the Society has been received and criticized in several quarters. One geologist, for whose opinion I entertain a high respect, wrote at once to intimate that he could not accept my conclusions; and when I naturally replied that he had not had an opportunity of reading the details upon which they had been founded, he replied that, "having seen the 'abstract,' he knew already quite enough to satisfy his own mind on the subject;" and I greatly fear my friend, who on a former occasion has openly expressed his impatience of long papers, will consign my production to the shelf or waste-paper basket when it reaches his hands, as he probably considers he knows enough of the matter.

The paper of Mr. Dakyns in the GEOL. MAG. for this month (July, 1877), is another case in point. It contains a *critique* on my paper as contained and represented in the "abstract" only; and of this I complain. If it had been based on a perusal of the paper itself, I should have been perfectly satisfied, whatever the conclusions of my reviewer might have been, because I would have been aware that he had all the data before him; and if these did not bring him to the same conclusions as myself, I should conclude that this was owing to the fact that his mind and my own are constituted differently; but I deprecate conclusions drawn from a partial knowledge of the facts.

I cannot now go fully into Mr. Dakyns' objections—time and space forbidding. I ask him, however, to mark the force of the term "essentially"—as used by me—and to recollect that it does not mean *exclusively*.

Then as regards the difficulty of believing the Gannister beds to be marine *essentially*—notwithstanding the large number of marine mollusca, etc., they contain—because of the occurrence of beds of coal in Scotland. This is not so surprising as the occurrence of beds of coal in Scotland overlaid by marine limestones, which shows that Nature accomplishes results which man sometimes cannot conceive.

As regards the term "Yoredale," Mr. Dakyns, as an officer of the Geological Survey, might surely have concluded that I have adopted the term as it is used by the Survey itself, whatever its original signification may have been. It may not be strictly correct, but it would be hard to find a better for the great series of beds above the Mountain Limestone of Derbyshire.

As regards the latter part of Mr. Dakyns' paper, does he hold the opinion under which I myself was enthralled till lately, that the great limestone series of the north of England and Scotland is all of it the representative of the true Carboniferous Limestone of Derbyshire and Lancashire? If so, I believe this to be a popular delusion, which I have endeavoured to prove as such in my paper. The true Carboniferous Limestone is, I believe, represented in the north only by the bed (or group of beds) known as "the Scaur Limestone" of Phillips, and in Scotland, as the Lower (or Roman camp) Limestone. The series of beds, limestones, ironstones, coals, shales, etc., which overlie this, being the representatives of the "Yoredale" beds only. Lastly, let me ask how is it possible to believe the Carboniferous rocks to be "one indivisible formation," if by that term is meant a heterogeneous collection of beds of various mineral characters, and of various modes of formation, in the face of the great fact of the predominance of marine limestones in the lower part, and their entire absence in the upper? So far from this being the general conclusion to which a survey of the Carboniferous rocks of the British Islands and the West of Europe would lead us, I have always found it rather difficult to prove to a student that the Lower and Upper Carboniferous beds really belong to one formation at all, so great is the contrast between the "essentially" marine aspect of the lower, and the essentially lacustrine aspect of the upper division. If this be so, is it not "philosophical" to suppose that there is a middle group, between these extremes, "essentially" marine, yet less oceanic than the lower stage of the Mountain Limestone?

Meanwhile, allow me to ask my colleague to defer his opinion on the views I have stated in my paper till he has had an opportunity of reading it. EDWARD HULL.

GEOLOGICAL SURVEY OF IRELAND,
Office, 14, *Hume-street, Dublin.*

THE RELATION OF THE PERMIAN TO THE TRIAS.

SIR,—Mr. Irving appears to have quite mistaken the purport of my communication on the relation of the Permian to the Trias in the neighbourhood of Nottingham.[1] I understood it had been stated by geologists of Nottingham, that not only a perfect conformity existed between the Permian and the New Red Sandstone near that town, but there was a passage upwards from one formation into the other.

I merely wrote to say this could not be, for the reasons I gave. But I never intended to imply there was not a general conformity between the two formations, for this general conformity must be apparent to any one on looking at a good geological map, whereon these formations are laid down. Neither did I intend it to be understood that I considered that the break between the Permian and the New Red Sandstone was greater than between some of the subdivisions of these formations. As, for instance, the break between the Middle Marls and Lower Magnesian Limestone of the Permian, or that between the Keuper and the Bunter of the Trias. I gave no opinion one way or the other on these points.

The point of my communication was this. The relation of the Permian to the Trias I considered an important problem yet to be worked out. If a perfect passage from the one up into the other was found, it would go far to settle the question. As far as I know, that passage has not been found, and, I contend, it does not exist in the neighbourhood of Nottingham.

Some personal remarks in Mr. Irving's communication I shall not reply to, they have nothing to do with the question, and were wholly uncalled for. I do not consider the pages of a scientific magazine the place for that kind of bantering. W. TALBOT AVELINE.

HURONIAN VOLCANIC ROCKS.

SIR,—In an able paper in your last issue, Mr. George M. Dawson publishes the results of his study of the "Porphyrite Formation" of British Columbia, and applies these results to the explanation of the origin of the Huronian series of Eastern North America. I am particularly pleased to find so good an observer as Mr. Dawson not only prepared to affirm that the Huronian rocks on the Lake of the Woods are in great part volcanic, but putting forward the theory that the Huronian formation is largely composed of metamorphosed contemporaneous igneous matter. This is the view to which I was myself led by my study of these rocks in the field, and I published this opinion in a paper on the Geology of the North Shore of Lake Superior some years ago (Quart. Journ. Geol. Soc. vol. xxix.). In this paper I expressed the opinion that the great masses of "talcose" and "chloritic" slates which, together with interbedded traps, make up the greater part of the Huronian formation between Lake Superior and Lake Shabendowan, are "truly of the nature of bedded felspathic ashes;" and I also drew attention to the singular resemblance which they present to the Borrowdale series, or Green Slates and Porphyries, of the North of England. It affords me, therefore, much pleasure to find that these views, at that time quite unsupported, should have been corroborated by the wide opportunities for observation and the extended experience of Mr. Dawson.

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[1] GEOL. MAG. Dec. II. Vol. IV. p. 155.

United College, St. Andrews, H. Alleyne Nicholson.
July 7th, 1877.

OBITUARY.

WILLIAM HARRIS, ESQ., F.G.S.

Born 1797. Died 1877.

With regret we announce the death of William Harris, Esq., F.G.S., on the 13th May, aged 80, at Charing, in Kent, where he had resided for many years. He was greatly esteemed by a large circle of friends for his genial disposition and real philanthropy; and he obtained deserved reputation for his untiring researches among the fossils of the Chalk, and into the geological history and structure of the country around him. He was elected a Fellow of the Geological Society of London in 1839. After a long life of useful activity his health failed him eight or nine years ago, and he gradually lost his power of moving about and attending to business, as well as his interest in those scientific pursuits which were formerly his pleasure. He had for many years assiduously collected the organic remains found in the Chalk-pits of the neighbouring hills, especially the Sponges and Fishes. Of the former he communicated many to Mr. J. Toulmin Smith, who figured and described the *Ventriculidæ* of the Chalk in 1848. Of the Fishes he collected and prepared a great many, but they were never classified. The enormous numbers of *Entomostraca*, *Polyzoa*, and *Foraminifera*, together with small Brachiopods, Serpulæ, fragments of Corals, Encrinites, etc., which Mr. Harris obtained, by careful and patient search, from the Chalk and Chalk-marl, were freely and liberally distributed to his friends, and to others interested in palæontology. Many a one has been instigated to take up geological studies, with microscope at home and hammer abroad, after participating in some of these minute organic treasures from "the Charing Detritus," as the disintegrated Chalk-marl of the locality was termed by our lamented friend.

Prof. W. C. Williamson, in 1847, figured and described some of the small fossils from Charing in his comprehensive and far-seeing memoir "On some of the microscopical objects found in the Levant, and other deposits; with remarks on the mode of formation of calcareous and siliceous rocks," Mem. Manchester Lit. Phil. Soc., vol. viii. See also the supplemental "Corrections of the Nomenclature of the Objects," etc., *op. cit.*, third series, vol. v. 1872. Dr. Mantell also noticed the excellent results of Mr. Harris's labours on the "Chalk-detritus" and its Animalculites in the sixth edition of his "Wonders of Geology," 1848, and in his "Medals of Creation," 1854, etc.

The Entomostraca from the same source were the incentive, and supplied the chief material for the "Monograph of the Entomostraca of the Cretaceous Formation of England," Palæontogr. Soc., 1849; and for its revision in the GEOLOGICAL MAGAZINE, Vol. VII., No. 2, February, 1870. Mr. Harris's collection of similar fossils from the Gault of Kent added largely to the completion of that Monograph.

Of the Foraminifera and other fossils thus collected at and near Charing, many increased the lists in the second edition of Prof. Morris's "Catalogue of British Fossils," 1854, and are duly acknowledged in the preface. Some small Brachiopods were worthy of Mr. Davidson's attention and description; and other rare fossils in Mr. Harris's collection are figured in Dixon's Geology of Sussex, etc.

Mr. Harris devoted much of his leisure to mapping the areas of the Cretaceous strata about Charing on the One-inch Ordnance Map; and the Geological Surveyors were pleased to avail themselves of his work as far as they could. In company with the writer, in 1854, he found the fossiliferous specimens of Tertiary ironstone in sandpipes of the Chalk near Lenham, which added so much to our knowledge of the "Kentish Crag," when studied by Messrs. Prestwich and Searles Wood (Quart. Journ. Geol. Soc., vol. xiv. p. 325, and p. 333). Mr. Harris also worked indefatigably in tracing the extent of this fossiliferous ironstone in his immediate neighbourhood; and he had diggings made, at considerable expense, on the hill above Charing to the depth of about 30 feet. Mr. Prestwich gives an account of these in his paper above referred to.

Thus, as one of the many quiet workers in rural districts, carefully observing nature, and looking with knowledge on antiquities, fossils, and all traces of the past, Mr. Harris took pleasure both in collecting and in communicating everything of use and interest that could be learnt within his field of observation. T. R. J.

JOHN LECKENBY, ESQ., J.P., F.G.S.

BORN 1814. DIED 1877.

It is with no ordinary feelings of regret that we record the loss of an excellent Yorkshire geologist, whose death leaves a sad blank in our circle of scientific friends. Mr. Leckenby was a native of Ripon; he came to reside at Scarborough upon his appointment to the York City and County Bank in 1837, then recently established. From that latter date the direction of his mind towards the cultivation of the natural sciences commenced; he quickly formed the acquaintance and friendship of Dr. Wm. Smith, who at that time resided at Scarborough, and also of Mr. William Bean and Dr. Lycett.

For several years he was known only as a diligent collector of the varied objects yielded by the coast of that part of Yorkshire, more especially of the recent shells, and he never ceased to add to and improve his collection of British Mollusca until, at his death, they had become, with a single exception (that of Dr. J. Gwyn Jeffreys), the finest collection of British shells known. About the same time (1837) the discovery by Mr. Bean of the considerable Oolitic flora in the shore-beds of Gristhorpe Bay and the publication of his specimens by Lindley and Hutton in their Fossil Flora of Great Britain, had an important influence upon the mind of so enthusiastic a young man as Mr. Leckenby, and materially aided in directing his attention to Geology and Palæontology. In the pursuit of the latter science it became his especial object to acquire the finest possible specimens, or, to use his own expression, "he loved to see nature with clean face and hands." His fine museum of fossils was transferred during these later years to the Woodwardian Museum at the University of Cambridge. He made several contributions to the pages of this MAGAZINE, and also to the Quarterly Journal of the Geological Society of London, vols. xv. xix. and xx.

His genial and hospitable disposition won for him a large circle of friends both in Scarborough and London. The progress of the fatal disease to which he succumbed was rapid, and dates only from September, 1876.

JAMES BRYCE, ESQ., M.A., LL.D., F.G.S.

BORN 1806. DIED 1877.

BY a deplorable accident Science has lost a most able geologist through the death of Dr. James Bryce, which occurred in the pass of Inverfarigaig, near Foyers, whilst on a geological excursion. He had sallied forth alone, hammer in hand, to examine the rocks in the pass, and whilst pursuing his researches on the top of the cliff he must have inadvertently stepped upon a loose piece of rock, which giving way beneath him, he was precipitated to the foot of the cliff, where, three hours later, his lifeless body was found by two gamekeepers.

James Bryce, son of the Rev. James Bryce, Presbyterian minister, was born at Kalleague, near Coleraine, in the north of Ireland, October, 1806. The greater part of his early education he received at home; but he subsequently went to the University of Glasgow, where he graduated, having specially distinguished himself in Greek, and carried off, among other honours, the Blackstone prize. After leaving College, he acted as mathematical master in the Belfast Academy, until, in 1846, he was appointed to superintend the Mathematical and Geographical Department of the High School, Glasgow. There he spent the greater part of his life, diligently discharging his daily duties and earnestly endeavouring to promote the teaching of science in schools when that was not so popular as now. In recognition of his services in this and other capacities, his Alma Mater in 1855 conferred the degree of LL.D. Three years ago he retired from scholastic work, and came to reside in Edinburgh, where, as in the West, his genial disposition, not less than his intellectual activity and varied acquirements, soon gained him a wide circle of friends. Prominent for many years among Scotch educationists, Dr. Bryce took an active part in founding the Educational Institute, of which he was President in 1852. In 1874 he was President of the Association of Higher Class Public Schoolmasters; and within the last few months he acted as secretary to the committee for securing the continuance of the Scotch Education Board. His contributions to educational literature were numerous, but to the general public he was perhaps better known as an indefatigable geologist. When quite a young man, he contributed many papers to scientific journals upon geological subjects, and in 1834 he became a Fellow of the Geological Society of London. When resident in Belfast, he carefully investigated the geology of Antrim, and particularly of the Giants' Causeway, and these researches, the results of which were published from time to time, threw not a little light on the character of basaltic formations. After removing to Glasgow, he devoted much attention to Arran, and in due time produced an excellent work on the geology of that remarkable island, now in its second edition. He made another important contribution to the London Geological Society on the rocks of Skye and Raasay. In Glasgow, Dr. Bryce took a warm interest in the proceedings of the Philosophical Society, of which he was President for two years. As convener of the British Association's Committee on Earthquakes, he conducted experiments at Comrie, regarding which interesting reports were made. During the three years he resided in Edinburgh, he was assiduous in attendance at the meetings of various scientific societies. Of the Royal Society he was a fellow and councillor; and of the Geological Society a fellow and senior Vice-President. Dr. Bryce, it may be also mentioned, was editor of a Cyclopædia of Physical Geography. For several years he has been working at the geology of the North West Highlands, to which he made many excursions. He was a keen and intelligent observer of geological facts; and outside the family circle seemed never happier than when travelling, hammer in hand, through a district which promised to reward research. It is a melancholy coincidence, that it had been intended to ask Dr. Bryce to lead the next excursion of the Inverness Field Club to the very glen in which he has so suddenly closed an active and useful career.—*The Weekly Scotsman*, July 14th, 1877.

MISCELLANEOUS.

Dixon's Geology of Sussex. 4to. 1850, pp. 454, with 60 Woodcuts and 44 Plates.—This fine work, published after Mr. Frederick Dixon's death, under the able editorship of Professor Owen, C.B., assisted by Professors Thos. Bell, F.R.S., Edward Forbes, F.R.S., Mr. Wm. Lonsdale, F.R.S., Mr. James De Carle Sowerby, and Sir Philip Grey Egerton, Bart., M.P., F.R.S., is, we understand, after an interval [redacted]enty-seven years, to see a second edition, prepared by Professor T. Rupert Jones, F.G.S.; assisted by Professor Owen, C.B., and numerous other geological and ogical friends. To be published by W. J. Smith, Brighton.

THE
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No. IX.—SEPTEMBER, 1877.

ORIGINAL ARTICLES.

-The Kessingland Freshwater Bed and Weybourne Sand.

By S. V. Wood, Jun., F.G.S., and F. W. Harmer, F.G.S.

WO papers in the July Number of this Magazine, one by Mr. J. H. Blake, and the other by Mr. C. Reid, impugn certain repretations given by us of beds on the Norfolk and Suffolk coasts, and nand from us some remark.

ls the paper of Mr. Blake, "On the Kessingland Cliff Section," s not introduce any new fact, either as to the section itself, or in tradiction or qualification of the evidence which was offered in joint paper in the Quarterly Journal of the Geological Society February, 1877, or in the separate paper by one of us in the e Journal, we have only to say that we have never advanced, do we entertain, any decided opinion that the freshwater beds the section are of interglacial age; and that we only suggested possibility of such a thing as a matter for consideration in conion with other interglacial features described by us.

So far as we can see, Mr. Blake's objections amount to this, that shwater beds with roots, overlain by the Lower Glacial beds, ur in Corton cliff, and in places on the Cromer coast; and that, refore, they are necessarily of the same age as those of Kessingd, which are not so overlain. On this point we beg to refer your ders to the observations made by us in the "Introduction to the plement to the Crag Mollusca" (p. xv), as to the improbability any denudation having so evenly removed the Lower Glacial ls (which must have once covered this district, since they occur in siderable thickness in the neighbourhood) without leaving a trace them, and yet have spared the root-indented surface of the untified bed of clay, throughout the whole length of the section, ich extends for more than a mile.

The interglacial denudation, with which we suggested in our it paper the bed in question *might be* connected, rests, however, far clearer evidence; and the very case which Mr. Blake would ume in explanation of the preglacial age of these freshwater osits, viz. the removal of the Lower Glacial beds before the osition of the Middle Glacial, involves the admission of such udation.

Mr. Blake says that the section given in the separate paper by one us, as well as the description, is inaccurate; but he does not cify in what respect; nor does he say anything about the series beds which Mr. Gunn shows in his section as intervening between the forest-bed of Kessingland and the Middle Glacial sands—beds which we say have no existence there;—but as Mr. Blake expresses an opinion that these forest-beds *in sitû* are undoubtedly identical with similar beds beneath the contorted drift in Corton cliff, and at Hasbro', and Runton on the Cromer coast, we may refer to the paper of his colleague, Mr. Reid, in which the existence of the forest-bed *in sitû* along *that* coast is called in question altogether.

It will be interesting to see the various views of the gentlemen of the Geological Survey brought into the harmony requisite for the Memoir on East Anglian Geology which Mr. Blake promises us.

With respect to Mr. Reid's paper we would observe:

Firstly. That the Norwich Crag and Chillesford Clay, which many have found, and some still find, at Weybourne and elsewhere along the Cromer coast, but which we have always contended do not occur there unless concealed beneath the beach, have no place in Mr. Reid's section. So far, therefore, we agree with him.

Secondly. That as regards the freshwater bed (No. 3) shown by him to be irregularly interposed between marine sands (2 and 4), Sir Charles Lyell, in his paper on Norfolk in the Phil. Mag. for 1840, showed that the freshwater bed at Runton (which we presume is part of Mr. Reid's No. 3) was both overlain and underlain by marine sands (the lower called Crag by Sir Charles). The improbability of a purely freshwater bed *in sitû* thus occurring as a mere patch, or rather lump, between marine sands without there being any transition into or out of it, raised doubts of its correctness, so that one of us, in his "Remarks and Map," circulated in 1865, suggested that nothing but a clean vertical section would be conclusive on the point. This section has since been made, and it appears that Sir Charles's representation was correct. The original difficulty therefore recurs, and the question arises whether this freshwater bed of peaty sandy clay, which is only a thick mass a few yards long, or any other similar patches, are beds *in sitû* or not. Mr. Norton seems to think that much of the long-quoted 'forest-bed' of the coast is not *in sitû*, and Mr. Reid expresses himself very decidedly as of that opinion. If this should prove to be correct, it might, were it not for Mr. Reid's statement that rootlets penetrate the sands, possibly explain the whole matter by showing that some parts of these peats and freshwater and forest remains along the Cromer coast are portions of the preglacial land-surface, which were stripped off by ice which formed over it, and were carried with it into the estuary, in the sands of which they became imbedded, in the same way that sheets of chalk, hundreds of feet long, and several feet thick, were stripped off the surface and carried into the Cromer Till just over these sands when, somewhat later, the formation gave place in the same estuary (as we take it) to that of the Till.[1] We are sceptical as to whether the indistinct markings in the sand which Mr. Reid believes to be rootlets are really such; and this point must be satisfactorily established before any division of these marine sands into two beds by the intervention of a land-surface can be admitted. The mere presence of the opercula of freshwater shells, or even of freshwater shells themselves, which Mr. Reid occasionally finds in these beds, cannot be looked on as conclusive of their freshwater origin, since freshwater shells are found in those parts of these sands which are undoubtedly marine, or at most slightly fluvio-marine. Apart, therefore, from the existence of the black peaty bed at Runton, but which may be explicable in the way suggested above, we have never seen anything in these Weybourne sands which would justify Mr. Reid's division of them into two marine beds, separated by a freshwater deposit or land-surface.

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[1] We have seen sheets of sandy peat also imbedded in the Till itself near Cromer; and in the sections of the Norfolk cliff which accompany the "Remarks and Map" circulated by one of us in 1865, the sands in question are about Sidestrand (where Mr. Reid represents his freshwater bed as intercalated between marine sands) described as charged with the débris of the forest bed with freshwater mollusca and [illegible] peat (h''' of those sections). With the exception of the lump at Runton, neither of

Thirdly. The passing up of the Weybourne sand into the Till is denied by Mr. Reid. We are surprised at this, for at many clean exposures which we have from time to time met with, this was clearly visible. It was so at Weybourne most distinctly; and it was so over the Runton peaty bed, where the sand with pebble seams below the Till alternates with bands of clay, indistinguishable from the Till itself; while between Cromer and Mundesley these beds arch up in great thickness above the beach, and, darkened by and interstratified with lignitic debris, change so gradually into the Till by alternation of pebble seams, chalky silt, and lignitiferous sand with clayey Till, that it is impossible to draw even an approximate line between the two deposits. On the other hand, there are near Hasborough distinct unconformities in the stratified material by which the Till and contorted drift are indistinguishably represented at that end of the cliff section, but these we regard as simply the effect of shoaling and of current action during the accumulation of these beds (see No. II. of the sections accompanying our map in the Supplement to the Crag Mollusca). It is obvious that if the two deposits, the pebbly sands and the Till, do not pass into each other, there must exist everywhere a line of denudation between them, because there could not have been an intermediate conversion into land without it; and this line should be visible everywhere along the coast where the section is clear, and not be confined to the dips or plunges shown in Mr. Reid's section, which seem to us only part of the disturbances caused by the grounding of bergs in the contorted drift, by which the Till and that drift have been in places affected, in common with the sands in question. We have also seen these sands interstratified with the Contorted Drift in the neighbourhood of Norwich, though Mr. Reid appeals to Mr. H. B. Woodward's experience of that neighbourhood to the contrary. The quarry by Guist Church shows, or did show, also, the same thing.

Fourthly. As regards *Tellina Balthica*, Mr. Reid is in error in sup-

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us has ever represented the forest bed and its associated freshwater deposits as *in situ* to the west of Mundesley, but only to the east of that place, where we still believe the freshwater beds with mammalian remains occur in that state, whatever be the case as regards the arboreal remains there.

posing that we have referred to it as a peculiarly Arctic shell. If he had remembered that it is found now living everywhere on the Norfolk coast, he would hardly have attributed to us such exceptional simplicity. What we have contended is that this shell, which is Arctic as well as West European, has not occurred in any bed of Crag age, notwithstanding various assertions to the contrary; and that therefore as it does occur (and always in abundance) in every fossiliferous marine bed of newer age than the Crag, it furnishes a clear palæontological horizon by which to divide the Crag from beds of Glacial age. With the exception of *Turritella terebra*, *Pleurotoma turricula*, *Ostrea edulis*, and a species of *Lacuna*,[1] all the marine shells mentioned by Mr. Reid as discovered by him in these Weybourne sands will be found in the Lower Glacial column of the tabular list in the "Supplement to the Crag Mollusca," or in the additions thereto given in the note to our joint paper in the Quarterly Journal of the Geological Society for February, 1877; and it is satisfactory to us to find, by the few additions only which have resulted from Mr. Reid's lengthened stay upon and study of this coast, that we had so nearly arrived, by our own researches, at the molluscan fauna of these Lower Glacial sands.

Lastly. If we understand Mr. Reid's paper aright, he thinks that the beds between the Chalk and the Till on the coast constitute only one formation, and that such formation is an estuarine one. This is what we have always contended, only we add to it that this formation is the same as the pebbly sands described by one of us in 1866, under the name of "Bure Valley beds," and afterwards by Prof. Prestwich in 1870 under the name of "Westleton Shingle;"[2] and also that the Till is merely a continuation of the same deposit, due to increasing depth of water combined with glacial action; and this is one of the very few things connected with the Glacial beds as to which we feel no doubt. If the pebbly sands thus characterized by *Tellina Balthica*, which form the base of the Cromer Till (or Lower Boulder-clay of Mr. Reid and others), are to be rejected from the Glacial formation, to which, although they may present no indications of glacial action, they structurally belong, because their marine fauna is not, as is the fact, more Arctic than the uppermost beds of the Crag (though both contain several species of mollusca that now live only in Arctic seas), then most assuredly the sands and gravels which we term Middle Glacial should be rejected also from the Glacial formation, because their molluscan fauna is even less Arctic than is that of the sands in question, while the relation borne by them to the Chalky clay which rests on them is at least as distinct as is that of the pebbly sands to the overlying Till. Both, however, in our opinion, are not only part of the Glacial formation, but the Till in the one case, and the Chalky clay in the other, are equally continuations of the sand deposits beneath them by change in the material deposited. We may add, also, in opposition to Mr. Reid's assertion that the climate, as shown by the land animals and plants, was no colder than at present, that Sir Charles Lyell ("Antiquity of Man," p. 262) stated that a Swedish geologist recognized among the lignite beds of the sands in question the remains of *Salix polaris*, now only known within the Arctic circle, and of an Arctic moss, *Hypnum turgescens*, only found living in temperate latitudes on the extreme heights of the Alps. Most of the land and freshwater shells mentioned by Mr. Reid, and referred to by him in support of his contention as still living in Norfolk, occur also within the Arctic circle; and the rest, there can be little doubt, are also denizens of the same region, though their presence there has not been actually recorded. Perhaps he will go on to tell us what forms of land or freshwater mollusca beyond what are known as from these or from Crag beds would, if present, indicate an Arctic climate. Seven or eight species belonging to the genera *Helix*, *Pupa*, *Succinea*, *Planorbis*, and *Lymnœa*, from Greenland, are given as distinct by Möller; but it is very doubtful wether these are anything more than well-known temperate-climate species.

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[1] The *Cardium Grœnlandicum* of Mr. Reid is no doubt the shell given in the tabular list which accompanies the "Supplement to the Crag Mollusca," as *Cardium Islandicum* with a ? These imperfect decorticated specimens of *Cardium* cannot be identified with any certainty.

[2] It is not our business to defend Prof. Prestwich's identification of the shingle at Westleton with these Weybourne sands, which the gentlemen of the Survey impugn; but with respect to the identity which they discover between that shingle and the mass which plunges into the Middle Glacial sand of Dunwich cliff, we beg to say that this shingle (gravel) was several years ago, when that cliff could be ascended at the spot, and closely examined, divided at one end from the Middle Glacial sand [illegible]ath it by a denuded remnant of the Upper Glacial clay, in the manner shown in [illegible] R, which accompanies the map in the "Supplement to the Crag Mollusca," haps this remnant may still be found if looked for.

In conclusion, we would observe that if Mr. Reid's diagram section is correct, the actual sections at and near the termination of the Weybourne cliff must have greatly changed of late years, for it is evident, from Prof. Prestwich's sections of the cliff between Sherringham and Weybourne (both those published in his paper, and those besides which were exhibited on its reading, all of which differ from ours only in representing the lowest part of the beds in question as Crag and Chillesford Clay), that during the period of his acquaintance with the cliff near Weybourne, he had not observed in it the somewhat thick freshwater bed which Mr. Reid represents as there extending continuously and intervening unconformably between marine sands; and our experience of those sections, except so far as concerns the reference of any part of them to the Crag and Chillesford Clay, is in accord with that of Prof. Prestwich.

II.—ACROSS EUROPE AND ASIA.—TRAVELLING NOTES.

By Professor JOHN MILNE, F.G.S.;
Imperial College of Engineering, Tokei, Japan.

(Continued from p. 346.)

Part III.—Perm to Ekaterinburg and Nijni Tagil.

CONTENTS.—Perm.—Across the Urals.—Ekaterinburg—Gold Mines of Beresovsk.—Ride to Nijni Tagil.—Mines of Nijni Tagil.

PERM is known to the Russians like Woolwich is to the English, as being a great cannon manufactory. It is said to employ 4000 workmen, and is the largest establishment of the kind in Russia. To see it one must go about three miles farther up the river. In driving there I passed a section of a whitish fissile-rock, which was apparently a local representative of the Permian strata. The most noticeable thing at the works was a large steam hammer, said to be the largest in the world. The weight of the head of this instrument is 50 tons, but when steam is employed the energy is equivalent to three times this amount. The anvil on which this falls is a solid block of cast iron, weighing 667 tons. Up till quite recently all the coal used at these works was brought from England, which naturally involved considerable expense. Now they use their own coal, which is found on both sides of the neighbouring Urals in great abundance, coke only being brought from England. This costs about £5 per ton. It was not until the evening of the 5th September that my carriage, in which I intended to cross the Urals, was engaged. I started in the middle of the night. For the first 65 versts (1 verst $=\frac{2}{3}$ of a mile) I saw nothing but a few fir-trees and quantities of birch, after which a white rock began to crop up at various points, especially at those points where we wound round or cut through some undulations which relieved what had hitherto been a melancholy flatness. Right and left of the road, which in many places seemed like a pleasant avenue of birches, were rolling plains of yellow corn and stubble land. These vast expanses of open land, which are chiefly used for the cultivation of corn, clearly indicated the cutting down of large forests, the clearing away of which appears to have influenced the rainfall, and consequently the flow of rivers. This wholesale cutting down of the timber seems to have had its greatest impetus at the time of the Crimean War, when the manufactories of St. Petersburg and other large towns were prevented from receiving their accustomed supply of coals from external sources. From these times the use of wood became firmly established, as it was found to be so economical, not only in its first cost, but, among other reasons, from its not burning up the fire bars of their furnaces as coal did.

The first village of any size that we saw upon the road was Kongar, just before reaching which there was a descent so steep that it necessitated the use of a drag. This I mention, because it never occurred again, the plan being to charge down one hill in order to acquire sufficient momentum to ascend the next. After we had left Kongar, I heard that there was a cave there, which my informant told me was worthy of a visit. We were now in an undulating country, the contours of which were smooth and round. Most of the hills were cultivated to their summits, but some few had a covering of trees. In the evening we found ourselves at the tenth station out of the eighteen we had to pass before this section of our journey, which was as far as Ekaterinburg, would be over. All the following day we were amongst the spurs of the Urals. The hills around us were only of a moderate height. Patches of trees upon their sides, and dotted on the plains and winding valleys at their base, gave to them a rural, park-like aspect. As we ascended, small streams grew smaller, and told us that the water parting which divides the two great continents was near. Large fat magpies, water-wagtails, and an occasional woodpecker were the chief we saw. A few flowers still remained in bloom; a pretty v Snap-Dragon (*Linaria vulgaris*) and the white heads of the petalous *Chrysanthemum inodorum* were common. The bell-d heads of a few Campanulæ, a purple Pansy (*Viola tricolor*), pike-like purple heads of *Veronica spuria*, and a few other s, including a *Melgedium hispodum*, which I believe is rare, also to be seen. But about the few plants I collected I will nore farther on. Above the flowers a few butterflies were ;,—the heavy flutter of a Camberwell Beauty, some brown laries and a white *Pieris*, all reminding me of the fauna l left at home. Notwithstanding the cheering aspect of bright relics of a fading summer, a yellow tinge upon the ing birches told me that the "fall" was near. During the —for we rattled along in our springless carriage continuously, customary when travelling in Russia—it was now cold, and e morning everything had a coating of hoar frost. After ng the River Chesovoi, we passed through a gap in some high which had for some time been before us, and which in fact d the central hard granitic core of this portion of the Urals, hen descended rapidly towards Ekaterinburg. We were now over the borders. Just before we reached the town, we d an undulating expanse of ground, where I collected, almost e last time upon my journey, a few more flowers. This undu- is a boss of crystalline rocks, partly dioritic. These are ently traversed in a north and south direction by numerous of quartz. Near some of these veins the rock had quite ile structure, and looked as if shales had been turned on arallel with the veins of quartz. All the surface soil appears derived from the disintegration of the subjacent rocks. It is iore than 1½ feet in thickness, and is filled with angular frag- of stone. The town of Ekaterinburg, which we reached late e afternoon of September 9th, is one of the finest towns in ia. It appears to have been built in a shallow saucer-like w. One of the employments of its inhabitants is the cutting rious minerals for ornamental purposes. The minerals chiefly are malachite and rock crystal. This latter, when of a smoky and often when clear, is called by its vendors topaz. One that is striking, not only in Ekaterinburg, but also in most of iberian towns, is the green colour of the roofs, especially the hes. This, I believe, is made from crushed malachite.

ıen in England, and during the greater portion of my journey Russia, I had the impression that on reaching Ekaterinburg uld find myself in the centre of the Ural Mining District. grass-grown heaps of rubbish, long-forgotten "dumps," which otted over the surrounding country, told me that Ekaterinburg e time might perhaps have realized my expectations. Except-ne or two small alluvial workings carried on in search of gold, iining days of Ekaterinburg are for the present past. The st works of any consequence are those of Beresovsk, which are about twelve miles distant. The mineral here sought is gold. Hitherto in Siberia all workings for gold have been by washing the alluvium, but here operations for the purpose of quartz mining are being carried on in an energetic manner, and at apparently considerable expense. From this fact, from the unusual mode in which the deposits occur, and I may add also from the historical associations connected with the Beresovsk mines, it being to these mines that many of the early Siberian exiles were condemned, it will not be out of place for me to relate the little I saw and gleaned during several visits that I paid to them.

For the privilege of making these visits, and for the kind hospitality I received whilst staying there, I have to thank General Astershof, their chief promoter, the resident director and engineer. My first journey to Beresovsk was on September 11th. Owing to the breaking of the axle-tree of our carriage and a fall of snow, we were detained a considerable time upon the road. The greater part of the way is along a wide open clearing through fir woods. Here and there I obtained a view over a wide flattish country, which appeared as if its surface had been overturned and washed at many points. As we neared the village of Beresovsk, which gives its name to the mines, I saw several freshly-opened pits and trenches, all indicative of gold-searching operations. The first discovery of this metal was made in the year 1745, when it was found at the same time by two men at places about 80 versts apart. At the outset all the workings were upon quartz reefs; but in 1823, gold-bearing sand having been discovered, the quartz mining ceased, and the works assumed a new aspect. These

venite). This strikes north and south parallel to the adjacent
towards which it also dips. It is very much broken, very
inous, soft, and generally irregular in its character. In one
ion it appears to merge into a kind of serpentine. Inter-
ied, so to speak, or at all events running parallel with the
of the talcose schists, are bands or dyke-like masses of a
ic rock, containing but little mica, called beresite.

se bands vary from 28 to 180 feet in breadth. An average
th is about 80 feet. As they descend, they become denser and
wer. In one shaft that I descended, which was sunk altogether
s rock, I had a fair opportunity of seeing its various characters.
the surface it commenced with its usual appearance of a white
which clay I was told was used for making fire-bricks; deeper
however, it appeared as a compact grey rock, which, owing
non-splintery character, had been finished off with as smooth
ace as that of an ordinary brick wall. These bands of beresite
ently occur in great numbers, and in the neighbourhood of
ovsk 157 have already been discovered. Sixteen of these are
the distance of six or seven versts as measured across their
. These, with the exception of three, which run east and
preserve a north and south course parallel with the adjacent

right angles to these bands of beresite, and also to the talcose
s, there are numbers of quartz veins, and it is in these latter
he gold is found. These veins are generally from three to
inches in thickness, but in places they have reached a thick-
f more than three feet. Like the beresite veins they traverse,
often thin out in going downwards. Their strike, which is
ally east and west, is apt to vary, and two or more of them
ntersect to form a pocket. Sometimes several small veins,
. at the surface appear as mere streaks, are found, as they
d, to unite together to form a solid course. Some of these veins
een traced to depths of nearly 500 feet. In looking at a plan
ortion of the workings, I counted thirty-seven quartz veins all
ng a strip of beresite not more than eighteen Russian fathoms
feet) in length, and in another plan I saw seventeen veins
ng a vein of similar length. In such places as these the
veins are of course very near to each other, but there are
where they are as much as 40 fathoms (280 feet) apart.
veins are either vertical or else dip steeply towards the north.
are often strongly coloured with oxide of iron. In places they
n a little galena, and occasionally a few specks of copper
s. It has been observed that the lodes are rich at those places
they cross each other, where they are much stained with
of iron, or contain the above minerals, and when they do not
n altogether in the beresite, but cut through into the rock
her side. On the other hand, where the veins or lodes are
ed to the beresite, when they are flat, that is, do not dip
t vertically, and as a rule as they descend in depth, they
ually observed to yield but little gold. Up to the date of

my visit these mines have yielded a little more than 609 pouds (21,924 lbs.) of gold from the stamping of 47,639,874 pouds of ore. This gives an average of $4\frac{87}{96}$ zol (zol=$\frac{7}{48}$oz.) of gold for 100 pouds of ore (1 poud=36lbs.). Some of the veins have yielded as much as an ounce to the ton, and some of the alluvium 12oz. to $1\frac{1}{2}$ tons. As an average analysis, out of 96 parts of gold, about 90 will be pure gold, whilst the remaining six parts will be silver, copper, and iron.

The only excursion which I made in the neighbourhood of Ekaterinburg besides that to Beresovsk was to Nijni Tagil, one of the great centres of the Ural mining operations. This lies about 156 versts in a north-west direction from Ekaterinburg. Notwithstanding the roughness of the roads, the snow, rain, frost, and general hardship of the journey,—which was of necessity performed "pereclodnoi," that is, in post carriages or carts, from which you and your baggage change at every station,—I never regret the undertaking, on account of the great interest and information I derived. On a greater part of the road, away upon our left, we could see the low, black-looking hills of the Urals, which in places rose in peaks and hummocks. The outlines were smooth, and there was nothing very striking in the scenery. About half way we passed a small gold-mine upon the left side of the road, where they were winding auriferous gravel from a pit. In some places, instead of sinking shafts to the auriferous bed, it has been thought just as economical, and more satisfactory, to remove the whole of the superincumbent strata. This was carried out to a great extent at the Tabalour mine, which lies about seventy versts north from noticeable in the mines where new explorations have led to the modification and alteration of many preconceived ideas.

The great feature in Tagil is its iron works. The largest of these, which are named after the family by whom they are possessed, are the Demidoff. At these works 2500 men and 350 horses are employed. Many of the shops and foundries are lighted by gas, which is made from wood,—200 cubic feet of wood giving about 800 cubic feet of gas. The roots of pine and the rind of birch furnish the largest quantity of gas. The light from this gas is poor as compared with that made from coal, the former being equivalent to about ten candles, whilst the latter is equal to about fourteen. It is however, cheap, one jet costing half a kopec (one-sixth of a penny) per hour.

Whilst walking over the works, I saw several things in various stages of completion, which, if I speak of them as they were described to me, will sound quite transatlantic. First, there was a turbine being cast with a wheel 24 feet in diameter. Then there was a new iron furnace being built; this was elliptical in form, 56 feet in height, and was intended to have a capacity of some 8500 cubic feet. To keep this going a blowing engine was almost complete, the blast cylinders of which were seven feet in diameter. This turbine, the blast furnace, and the blowing engine, I was assured, were the largest in the world. As regards the turbine, this off-hand statement may perhaps be true, but larger examples of blast furnaces and blowing engines may be seen at home, as at Middlesborough.

The sand which is used for casting is derived from a weathered greenstone; but as this is somewhat calcareous, it is not so good as might be wished. Every year the manufactured steel, iron plates, bars and other materials are transported in waggons over the Urals to the River Chesovoi,[1] where they are placed in boats, each carrying about 400,000 lbs. About 150 boats are used annually. From the iron works I walked over to the Copper Hütte. From the commencement of the mine here in 1814, up to the year 1874, 152,671,193 pouds (1 poud = 36 lbs.) of ore, which yielded 5,001,016 pouds of copper, have been extracted. The yield of copper from the extracted ore has been therefore about three per cent. Close by these works there is a museum, where specimens of the raw and manufactured materials which are produced in Tagil can be seen. An interesting object in this museum was a large natural magnet, which supported about 10 pouds (400 lbs.).

Before describing what I saw of the mines, I will give the following as a short general geological description of the country around Tagil, in which these mines are situated. The information enabling me to do this I derived from a local topographical map, coupled with what I saw and what was kindly told me by a resident mining engineer.

All the country around Tagil, as I have before said, is very hilly. The highest of these hills look down upon the town from the west.

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[1] Spelt *Tchusovaya* in Keith Johnston's Atlas.

The iron mines of Tagil lie in a small hill upon the north side of the town. This hill appears to form a portion of a more or less metalliferous band, running north and south parallel with the Urals. This band consists mainly of felspathic rocks. On the east it is bounded by rocks similar to those of which it is composed, and on the west by a white highly crystalline slightly magnesian limestone. Throughout this band there are isolated patches of limestone slate and magnetic iron-ore. The small hill which I have mentioned is a mass of this ore, and in it are situated the mines or rather quarries of iron.

The form of this hill is somewhat ellipsoidal. Its height is about 280 feet, and its length about two miles. The ore is in many places coloured green, with stains of copper.

Penetrating through this huge mass of ore are small bands or strips of felsite, which run north and south; but, with these exceptions, the remainder is pure magnetite. An east and west section, at right angles to the length of this mass of ore, would seem to indicate that it probably thins out as you descend in depth. The hill is divided into five properties, each of which is worked in large open quarries. The face of one of these quarries upon the S.W. side of the hill is about 150 feet in height, and is worked in a series of horizontal benches or steps. Whilst walking about these quarries, I was much struck with the appearance of many large slickensides. The scratches on some of these were half an inch broad, and long and regular, covering patches two yards square; in many cases not at all unlike the effects of glaciation.

Some of these surfaces gave evidence of movements having taken place at different periods. The metalliferous band in which this

Part IV.—The Middle Urals.

Contents.—Nijni Tagil to Ekaterinburg.—Appearance of the Urals; their age; their geological structure.—The Coal-measures of the Urals and of Moscow.—Explanation of the intercalation of beds of limestone.—The land of the Carboniferous period in Russia lay to the West.—Coal-fields of Siberia.—Peculiarities in the distribution of the Fauna and Flora of the Urals; their geological bearing.

IT was the 18th of September when I left Tagil and returned to Ekaterinburg. The drive back along the flanks of the Urals was even more disagreeable than it had been when coming, and much of the interest was lost by repetition. The ponds were frozen, snow fell, and the roads were, without any exaggeration, like ploughed fields which had been frozen, jolting over which both night and day in an open springless carriage by no means enhanced our pleasures. Before I leave these mountains, I will here give a general statement of my few and imperfect observations as taken from my "omnium gatherum" of fragmentary notes. Some idea of this line of hills—which form more or less a barrier between the two great continents—may have perhaps been gleaned from what I have said concerning my journey across them when first I entered Ekaterinburg, and also when referring to my journey along their eastern slopes towards Tagil. They would appear to be a low undulating line of hills covered almost to their summits with vegetation, rather than that black formidable-looking Alpine range which they might be taken for if we were only to inspect a map of Russia or Europe. But as the point about which I speak is the place where the road between Perm and Ekaterinburg—the highway between Russia and Siberia—crosses into Asia, we might, notwithstanding the blackness of the maps, anticipate the truth, and conclude that, if the Urals at any point approximate to gentleness in their contour, it would be most probably there where the great Queen Catherine built her Siberian gateway, the town of Ekaterinburg. Further to the north, however, the hills, although not possessing any striking grandeur, are much rougher and higher; but nowhere along their whole meridional length of 1250 miles do they anywhere appear as physical features of great importance. Their highest point is only about 6000 feet.[1] In fact, as a long range of mountains, occupying such an important position in the divisions of the world, they are rather remarkable for their want of elevation and boldness of outline. However, they are extremely old. The Alps, the Pyrenees, the Apennines, and the Himalayas, appear to have been wrinkled up in Tertiary times; but the Urals were raised before even the strata of these great mountains had been deposited. The period at which they were formed is usually assigned to the close of the Palæozoic age, before the deposition of the Permian; but from what I saw and gathered I should be inclined to think that there is a great probability of their being somewhat younger, perhaps post- rather than pre-Permian. This, however, would not materially alter the length of time their heads have been lifted up against the weathering influences of time. From the deposition of the Trias down to the deposition of the alluvium, which covers areas of vast extent upon the Siberian plains, and up to the present, they must have seen many changes and suffered much degradation, all of which has tended to reduce their original height and bring them to their present form. There is only one other range of any importance which has had time to see and suffer more, and that is the line of hills in Scandinavia which date back to Silurian and Laurentian times. At times the Urals must have stood up like a range of islands, during which period sediments were deposited like those we now see upon their flanks. From the beds of alluvium which I saw in and near Tagil, lying in thick patches high up upon their sides, they must at no very remote period have been almost totally, if not quite, submerged, the surrounding waters being probably fresh, and perhaps the same as those from which the Siberian drift was deposited. In Triassic times the waters were probably salt.

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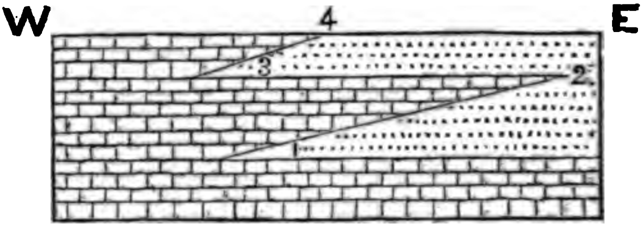
[1] "The northern Ural is more considerable, jagged mountain peaks rising to the height of from 5000 to 7000 feet above the sea."—Ansted's Physical Geography, p. 82.

But before saying anything more about these mountains, I will give a general geological sketch of their structure, as compiled from information I derived in Ekaterinburg and Tagil, which of course relates especially to their appearances in the vicinity of these two localities. If we made an ideal section across the middle portion of this range of mountains, we should see that their nucleus is granitic. This does not appear at all points to occupy the highest position as a saddle to the range, as for example near Nijni Tagil, where, from a cursory examination, a Silurian limestone seems to form the highest ground. Moreover, these central granitic rocks do not occur as a single boss, but rather appear to protrude at several points. Thus near Ekaterinburg, upon the eastern side of the mountains, there are three protrusions of granitic and porphyritic rocks. Right and left onably infer that, since the time of the accumulation of these ta, little or no disturbance has taken place, and that the eleva- of these mountains, as before stated, was at least antecedent ıe deposition of the Trias.

' the Permian strata are also undisturbed, which I doubt, it ld make the date of elevation of these mountains somewhat ier (see Ramsay on "The Geological History of some of the ntain Chains and Groups of Europe," Mining Journal, January l, 1875).

arboniferous Formation.—Of all the formations which help to d our Continents, the one perhaps most sought for is that which ls us Coal. These formations in Russia, as in Britain, show ırences in stratigraphical character, and also in some other points, n examined over districts which are distant from each other. refore, for purposes of comparison, before I commence with the ›oniferous strata which flank the Urals, I will state the general litions under which coal exists farther to the west, near Moscow. ımencing with the upper beds, we get three great zones, the ›st of which contains the coal, and overlies the Devonian. The of these zones is a limestone holding *Fusulina cylindrica*, the nd is a limestone with *Productus gigas* as its characteristic fossil, the third, which I have said holds the coal, consists mainly of -slate, with *Stigmaria ficoides*. Comparing this general arrange- :t with one that may be observed upon the western or Russian of the Urals, we find that the three zones of the Moscow district now represented by five zones, which also overlie the Devonian. upper one of these, which was called by Murchison Millstone- , on account of its lithological and stratigraphical resemblance to lar rocks in Britain, forms, I believe, the Etage d'Artinsk of M. pensky. It contains three bands of limestone, which in one ction thin out. Beneath this upper zone is a *Fusulina cylindrica* ›stone, and, still lower, a sandstone and clay-slate rock carrying . These last two zones, inasmuch as they overlie a limestone :aining *Productus gigas*, may be looked upon as being the equiva- of the *Fusulina*-limestone of Moscow, both of them occupying ewhat similar positions. Beneath this last limestone, which in West Ural series will form zone number 4, come more sandstones coal, which overlie the Devonian. Judging from a series of rock ıimens which I saw taken from zone number 1, they appeared represent a quartziferous sandstone much finer-grained than generality of rocks from our Millstone-grit. The limestone ls, which are intercalated in this zone, may probably be con- ›ed together, and also with the *Fusulina*-limestone below, their tion being an intercalated overlap indicating that some physical ıge, such as oscillation, had taken place during their deposition. accompanying figure will illustrate my meaning, and perhaps ;est an explanation for similar occurrences which have been ›rved in other parts of the world. At the end of the section, ked W, we get a series of limestones which may correspond to *Fusulina*-limestones near Moscow. At the opposite end of the



section, marked E, we find a series, the upper three parts of which are respectively sandstone, *Fusulina*-limestone, and sandstone, and correspond to the West Ural section. An appearance of this sort might be explained by assuming that the limestone was deposited in deeper water than the sandstone. After the limestone had been deposited up to the point 1 in deep water, by oscillation the sea became shallower towards the east or E, and the limestone then became covered as far as the point 1 with deposits from shallow water.

Next we may imagine the water to have deepened, and the limestone, so to speak, encroached upon these deposits which were being laid down in shallower water. In this way it was enabled gradually to overlap the sandstone as far as the point 2, when another oscillation in the opposite direction set in, and the agencies producing the limestone had to retreat towards deeper water before the advancing heavy gritty material of the shore-line. At the point 3 the limestone is indicated as again advancing towards 4, which would suppose still further oscillation. If the intercalations of limestone amongst sandstone in the Ural mountains be of the nature I have here suggested and described, it is possible that they were produced in the manner indicated.

One great distinction between the sections of the Coal-fields upon the Western Ural and those to the south of Moscow, is that the former contain many large beds of sandstone which are absent from the latter. Just as we are able to infer from somewhat analogous changes which are observed when travelling northwards over the Coal-measures of Great Britain, that much of our early Carboniferous land lay somewhere towards the north, so may we infer that much of the Carboniferous land of Russia lay somewhere towards the east rather than to the west.

Upon the eastern or Siberian side of the Urals the sections of the Coal-measures present still greater differences as compared with the Moscow series. So far as explorations have yet been carried, all the upper stages which we have mentioned in the other sections are apparently wanting, and we commence with the *Productus*-limestone. Beneath this comes sandstone and conglomerate, amongst which small quantities of coal are found. Still lower there is a second limestone, also containing *Productus gigas*, which overlies sandstones and conglomerates, amongst which true beds of coal with underclays occur.

After this a third *Productus*-limestone is found, which rests unconformably upon the underlying Devonian. The repetition of this *Productus*-limestone may perhaps be explained in a manner similar to that which I have suggested as an explanation for the intercalations of the *Fusulina*-limestones on the western side of the Urals.

The general relations of these three coal-fields are shown in the following table:

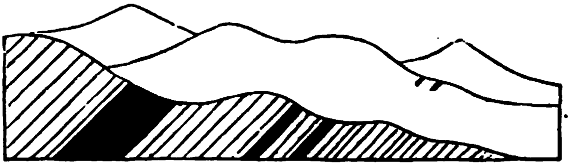
	South of Moscow.	West of Urals.	East of Urals.
I.	1. Limestone with *Fusulina cylindrica.*	1. Millstone-grit. 2. Limestone with *F. cylindrica.* 3. Sandstone, slate, and Coal.	
II.	2. Limestone with *Productus gigas.*	4. Limestone with *Productus gigas.*	1. Limestone with *P. gigas.* 2. Sandstone, Coal and conglomerate. 3. Limestone with *P. gigas.* 4. Sandstone, conglomerate and Coal. 5. Limestone with *P. gigas.*
III.	3. Clay-slate with *Stigmaria ficoides* and Coal.	5. Sandstone and Coal.	
	Devonian.	Devonian.	Devonian.

As the materials which form this table, and the description I have given, were collected from verbal information and the little that I saw, they must only be taken as giving a general outline of the chief geological features of this district, which will shortly be published in St. Petersburg with detail and accuracy.

Up to the present time little or nothing has been known about the existence of coal upon the eastern side of the Urals. At many places it has, however, been discovered, as at Geogorshina, Irbitskeeya, Vershene, etc. The general dip at these places is S.W. *towards* the Urals. In the northern parts it is more anthracitic than in the south, but this seems to be connected with the fact that there it is more bent and contorted, owing to its approaching more closely to the crystalline rocks. Some specimens from the abovementioned localities had this character, and they were also very friable. Their friability resulted from the numerous small joints by which they were traversed. Some of these joints were stained with iron, others held a small quantity of loose carbonaceous dust, whilst a few contained a white talcose mineral. The thickest seam yet found on this eastern side of the Urals is between six and seven feet, but this is divided by some clay partings. The thickest seam in Russia is, I believe, in the Solekamsk district on the River Lama, about 350 versts N.W. from Ekaterinburg, which is reported as being forty-two feet in thickness. It is described as being bituminous and containing many earthy partings.

These coal-fields on the eastern flanks of the Urals are by no means the only coal-fields which have been discovered in Siberia. Farther east, in the neighbourhood of Tomsk, anthracite has been found, whilst more towards the south, in the Kirghis Steppes, no less than sixteen seams have been found at the Ruanda Mines.

These were described by Mr. Wardroper, an English resident at Tumen. They occur in a hilly country, traversing both hill and dale over a large area, as shown in the accompanying sketch, where three seams are shown in section, two of which are seen cropping out upon the slope of the distant hills.



Beneath some of the seams there is an underclay, and above them bands of ironstone. One of the seams is about 5 ft. 10in. thick, and dips about three inches to the foot. The associated rock is a soft sandstone, of which I saw several specimens. The character of the coal is not unlike some of the Scotch splint coal. The smaller seams are generally better than the larger ones, being freer from impurities. Still farther east, in the neighbourhood of Irkutsk, on towards the Amoor and on the Amoor itself, considerable quantities of coal have been found. The characters of these seams are those of better class lignites, and their age is apparently Jurassic.

Whilst in Ekaterinburg, my attention was daily attracted by batteau firing in the neighbouring woods; going in that direction, I found that it arose from the guns of squirrel-hunters. Squirrels, like other animals, wander in search of food, and they were then in numbers round Ekaterinburg, though not seen at other seasons.

Comparing the Fauna on the two sides of the Urals, there does not appear to be any striking difference, except in the case of one small mammal, the common house or brown Rat, which is at present, I believe, only to be found upon the western side of these mountains, —that is, in their central and northern parts. The head-quarters of this rat appear to be at Astrachan, where it exists in such numbers as to give rise to stories, which, if repeated, would be thought incredible. It extends all over Europe, and up the Volga and its tributaries, to the very foot of the Urals, and here it appears to stop. So far as boats and railways have gone, the rat has gone also. It was conveyed by ship from Scandinavia to England, where it has almost exterminated its black congener (*Mus rattus*), the aboriginal species. In a similar manner it reached California, and probably also China, Japan, and Amoorland. Wherever it has landed, it has thriven rapidly, and often, whilst securing its footing, it has rooted out some pre-existing species.

At present a line of rail is being built across the Urals from Perm to Ekaterinburg, and for this the rats are waiting. Strange as it may seem that rats should wait for trains, no sooner is one ready for them than it seems certain that they will commence their march eastwards into Siberia.

Here we have a modern example of a new species appearing suddenly in an area, analogous to those sudden appearances met with in palæontological records. In such records we may, however, notice that these new appearances are sometimes coincident with, or else rapidly succeed, the dying out of some form which seems never to return. A recent example of this sort we may draw from the same districts we are now considering.

This example is the Beaver, which, if not quite extinct, is certainly an almost unknown animal. At one time it inhabited the whole of Europe and Western Asia, but now it is doubtful if many survive, excepting in a few districts where they have received protection. In Bavaria, where they appear to have become extinct so late as 1860, there are no less than sixty places, like Biberach, Biberfeld, etc., all testifying to their former abundance. Reading Murray's "Distribution of Mammals," one might expect to find them yet existing in considerable numbers in the streams of the Ural Mountains; but from all that I could learn, I think that this is not the case. In times gone by it used to be found upon the River Boroslovsky, but even there they have been exterminated. In 1859 two beavers were seen on the River Kakoia. In 1873 one, probably a descendant of this last-mentioned pair, is said to have been seen, and this is, I believe, the last record of beavers in the Urals. Further to the north, however, there are many rivers to be explored, where there is a possibility of still finding the creature; but of its actual existence I could not gather any information.

Looking all over the Asiatic Continent, although it was often stated to me that the Beaver was to be found in such localities as Yakutsk and Irkutsk, as I approached these places the animal appeared to be as far off as ever. The Yakutsk merchants obtain the skins they sell from the Tchucktians, who in turn obtain them from the neighbourhood of the Anadyr River, and perhaps also from the western part of North America.

The hare (*Lepus timidus*) is an animal which is rarely seen on the eastern side of the Urals, whilst upon the west, especially in Central Russia, it is very common. In the case of some species, as the Reindeer (*C. tarandus*) and Moose (*C. alces*), the Urals form an elevated pathway by which inhabitants of the north are enabled to descend towards the south without suffering greatly from any change of climate.

Besides the above two species of deer, *C. capreolus* is also a common inhabitant of the Urals. In the Middle Urals the Bear (*Ursus arctos*) is to be met with in considerable numbers, indications of its abundance being found in the seal of the Government of Perm, the effigy on which *is a bear.*

Although many fish are common to the two sides of the Urals, there is a greater difference between those on the east and those on the west than that which appears to exist between the Mammalia. Considering the difficulties that fish have in crossing a barrier of land, this might naturally be expected. As examples we have a species of Carp, *Alburnus lucidus*, only on the west side, and the *Guiniad*, *Coregonus leucichtys*, one of the *Salmonidæ*, only on the east.

Upon the eastern side of the Urals we have a singular example of the spread of a species in a district it was brought to colonize. This is the Crawfish. Up to the year 1843 or 1844 it only lived on the western side of the mountains, but about that time it was carried over, and now the eastern rivers of the Middle Urals are alive with Crawfish.

During the few weeks' ramble I had amongst the Urals, the season was too far advanced for the collecting of many plants. However, to the great surprise of a resident botanist, Mr. Onsième Clèrc, I obtained a few, one or two of which proved to be of rare occurrence.

Mr. Clèrc's observations tend to show that the plants in their geographical distribution about the Urals exhibit similar peculiarities to those I have noticed as occurring amongst the animals. Thus we have plants peculiar to the western side of these mountains, as *Asarum europæum* and *Ajuga reptans*, and I may also add, I think, *Primula lorella* and an *Auricula*. Then there are plants which are seldom seen upon the western side, but are common in Russia, as *Veronica officinalis*, *Bunias orientalis*, and *Tragopogon orientalis*. Certain plants, as might naturally be expected, are only to be found upon the high mountains of the North Urals; for example, *Salix reticulata*, *S. herbacea*, *S. rotundifolia*, *Dryas octapetala*, *Saxifraga punctata*, *Pyrethrum bipinnatum*, and *Asplenium crenatum*. Then, again, there are plants which have only been found in the Alps and near St. Petersburg, in addition to the Urals, as, for example, *Hieracium prenanthoides*. Again, certain plants which are found in the Urals stretch eastward into Siberia, such as *Caltha natans*, *Actæa spictata*, *A. oxycarpa*, *A. leucocarpa*, and *Aconitum volubile*. Other plants have an excessive range in this direction; thus *Rubus humilifolius* extends to the Amoor, as also does *Ranunculus Purschii*.

Thus we see that the Urals, although not forming a formidable barrier in the physical configuration of the globe, still play the part of one in preventing an unlimited mixture of species, which is alike evident both amongst the animals and vegetables,—a fact which, when regarded geologically, is of considerable significance, more especially when we reflect upon their great antiquity.

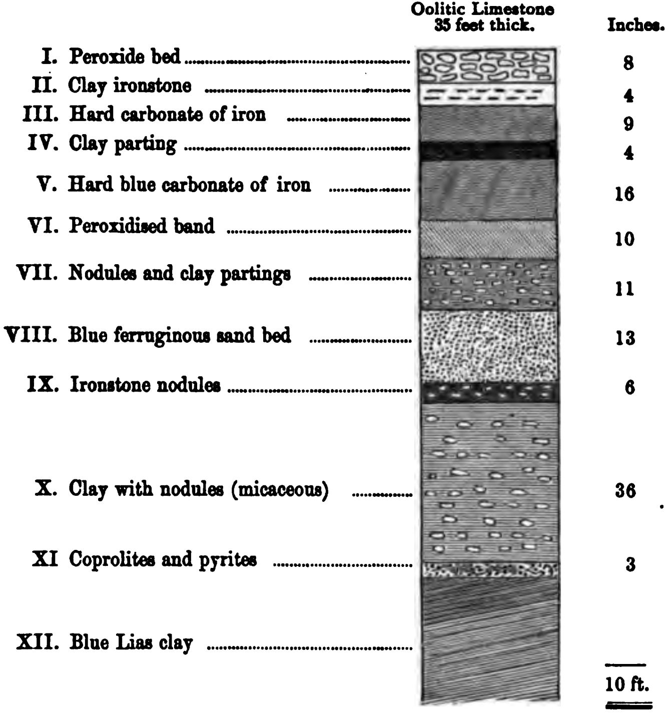
(*To be continued in our next Number*).

III.—THE NORTHAMPTON IRONSTONE BEDS IN LINCOLNSHIRE.

By CAPTAIN MACDAKIN.

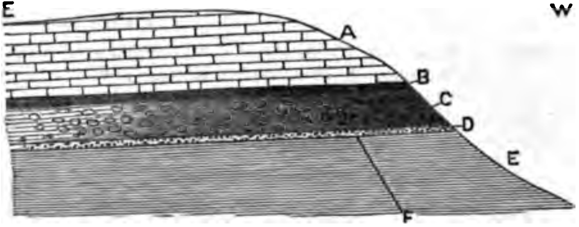
THE Ironstone Beds of Oolitic age in Lincolnshire have, during the last four years, yielded not only large quantities of brown hæmatite iron-ore, but some very interesting sections and borings, comprising thirty-one of the latter between four and seven miles to the south of Lincoln, and several extensive openings showing that the beds are much richer at this distance from Lincoln, but that they become very siliceous and pass into a ferruginous sand above Normanton about eighteen miles to the south.

Fig. 1.—Section of the Northampton Ironstone beds eight miles South of Lincoln.


Oolitic Limestone 35 feet thick.
Inches.
I. Peroxide bed
8
II. Clay ironstone
4
III. Hard carbonate of iron
9
IV. Clay parting
4
V. Hard blue carbonate of iron
16
VI. Peroxidised band
10
VII. Nodules and clay partings
11
VIII. Blue ferruginous sand bed
13
IX. Ironstone nodules
6
X. Clay with nodules (micaceous)
36
XI Coprolites and pyrites
3
XII. Blue Lias clay
10 ft.

In the physical geography of the country, the Northampton Sands occupy the upper part of the escarpment (Fig. 2 B, D), known as the Cliff, running roughly parallel to the Great Northern Railway (Fig. 4) from Grantham to Lincoln. At about a quarter of a mile

Fig. 2.—Section of Cliff showing in the shaded portion of C, the oxidised outcrop of the iron bed.



A, Lincolnshire Limestone. B, Lower Estuarine bed. C, Northampton Ironstone bed, oxidised from the outcrop towards F, this bed being ten feet thick. D, the Coprolite bed four inches. E, Lias clay.

Fig. 3.—Diagram, showing the slipping back and faulting of the beds over the Lias clay in the Greetwell cutting.

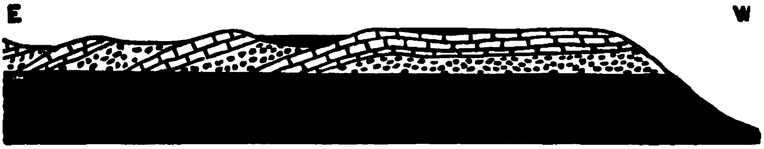
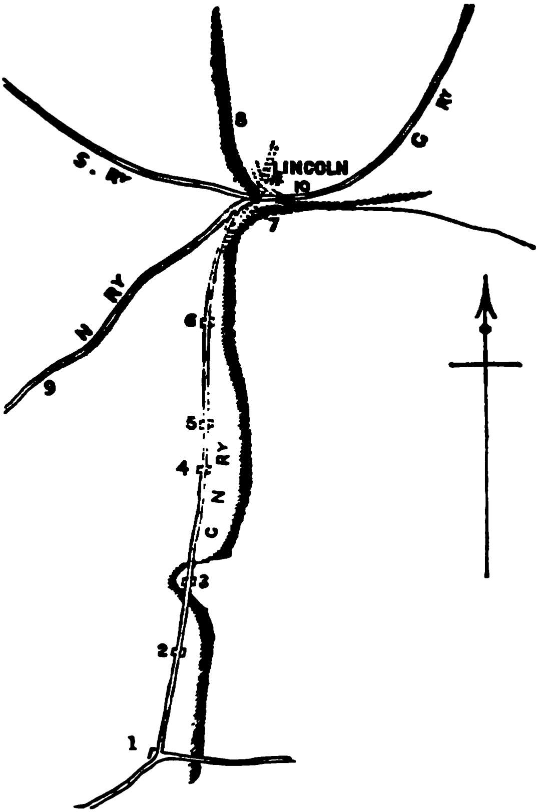


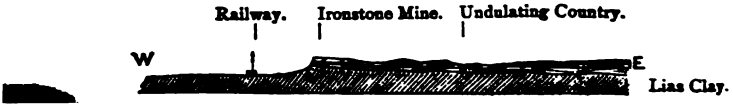
Fig. 4.



Explanation of Map. — 1. Normanton. 2. Caythorpe. 3. Leadenham. 4. Navenby. 5. Coleby Mines. 6. Waddington Mines. 7. Canwick. 8. Burton. 9. Scarle Boring for coal. 10. Greetwell cutting.

S. Ry. = Sheffield Railway. G. Ry. = Grimsby Railway. G. N. Ry. = Great Northern Railway. The escarpment is shown by a shaded line.

Fig. 5.—Section at Waddington.



istant from the Great Northern Railway, and overlooking the broad alley of Lias Clay, the top of the escarpment is formed of the enuded edge of the Lincolnshire Limestone (Fig. 2 A). The orings near the edge show a thickness of the Lower Oolite, Lincolnhire Limestone, of four feet, suddenly thickening to thirty feet or airty-three feet, and maintaining this thickness to the eastward. he surface is almost entirely level for about a thousand yards from he edge of the escarpment, and then breaks into a succession of light undulations (Fig. 5), until it is lost under the beds of Lower olite Clay or beneath the drift.

From personal observation I believe these undulations to have een caused by the upper beds having slipped in the direction of their ip, over the Lias Clay, which retains the water that percolates hrough the Oolite beds and Northampton Sands. This folding of he strata may be seen to advantage in the railway cutting on the rimsby line at Greetwell (Fig. 3), about a mile from Lincoln, ith the Lower Estuarine Clay forced up here and there where the imestone has been fractured. This escarpment is about a hundred nd fifty feet in height, the whole being formed by the Lias Clay ith the exception of the upper ten feet, which is Inferior Oolite. he top being scattered over with drift pebbles, which I have failed o detect in the Lias valley nearer than a mile and a half, when they gain commence and form extensive gravel-pits at Boultham Moor.

The Lower Estuarine series is next encountered, varying from ighteen inches to two feet, consisting of a very white sand and laggy sandstone, and in some places of clay.

Below this come the Northampton Ironstone beds (Fig. 2 C, and ig. 1), having a very constant thickness of eight feet, and resting n the Upper Lias. The ironstone beds vary in richness and in heir mineral characteristics: whilst the upper beds are siliceous, the ower beds are more argillaceous; some of the richer bands contain as nuch as forty per cent. of iron, which in the more siliceous portions alls to twenty-eight per cent. The ore near the outcrop occurs in odular masses on an average perhaps of a foot in diameter, someimes as geodes with concentric bands of oxidation, and occasionally ontaining a loose kernel of unoxidised blue carbonate of iron. For wo hundred yards from the outcrop the beds are of a deep reddish rown colour owing to the silicate of iron; then changing (Fig. 2 F) nto the bluish grey carbonates (Fig. 1); the red ore occasionally ining fissures plainly showing the cause of this change, from the riginal blue carbonate by oxidation to the brown clay ironstone odules of the outcrop, which even still in some places exhibit on racture a centre of the original blue carbonate of iron. Some porions of the peroxidised beds are very vesicular, the well-sinkers aving from time immemorial called it "Firestone," believing it to ave been the work of subterranean fires.

Immediately over the Lias Clay there is a curious bed (Fig. 1, o. XI.), three inches in thickness, of phosphatic nodules, with yrites, handsome brilliant masses, that the country people carry off s decorations for their chimney-pieces. A bed of micaceous clay

(Fig. 1, No. X.), sparkling like the scales of a fish, also excited much curiosity among the natives.

The siliceous ironstone is very difficult to fuse in crucible experiments with the usual proportion of limestone fluxes, even in the intense heat of a puddling furnace; but I found the blue Lias Clay an excellent flux, deducting of course the iron it contains (about four per cent.) from the result. Fossils were very scarce, and only the usual Inferior Oolite specimens, with a few small phosphatic nodules being occasionally met with of about an inch in length by half an inch in diameter, in the Northampton Ironstone bed.

Several chalybeate springs find their way into the valley, and form thin patches of re-deposited iron ore. The dead leaves and twigs at the bottom of ditches being sometimes covered with crystalline feathers of peroxide of iron, as bushes and trees are occasionally decorated with hoar frost in winter.

IV.—GEOLOGY OF THE ISLE OF MAN.

By HENRY H. HOWORTH, Esq.

IN a recent visit to the Isle of Man, I spent three long days in examining the deposits of the very interesting district in the south of the island, and I wish to draw the attention of your readers to some facts which are, I think, important. Not being an experienced geologist, I hope I shall do so with becoming modesty, and I should feel very gratified if some more practised geologist would verify my statements, which are, however, not rashly made, as I have sifted the question with care and patience.

f a conglomerate, and occasional pockets and layers of consolidated
ne red mud. The whole thickness is not more than twenty feet at
ny point. The conglomerate consists of a very closely packed
eries of boulders, some of them rounded and some with their
dges sharp, imbedded in a matrix of consolidated red mud, similar
› that just mentioned.

The boulders just referred to are of various sizes, from a foot and
foot and a half in diameter to small pebbles, and, so far as a careful
nd prolonged examination could discover, consist almost entirely of
ieces of limestone and quartz, the limestone forming about $\frac{9}{10}$
f the whole. These limestone boulders are some of them of the
atural colour of the limestone, and others are deeply coloured with
ron. These boulders are most clearly of Mountain Limestone, and of
he same character as the bedded limestone close by, and but for the
olour of a number of them, there would never have been any doubt
hat they were formed out of the disintegrated limestone. Again,
he muddy matrix in which the boulders are imbedded, as well
s the intercalated pockets, consists of a paste made up largely of
ulverized limestone.

These facts seem to admit of but one conclusion. A conglomerate
onsisting almost entirely of limestone boulders, imbedded in a
iatrix of pulverized limestone, lying immediately in contact with
eds of limestone, cannot well by any process of reasoning be made
ito an "Old Red Conglomerate." Unless there be some reason of a
ery marked kind to the contrary, the conclusion is inevitable that it
as been formed of the disintegrated beds of Mountain Limestone,
nd is posterior in date to them.

Thirdly, as to the position of these beds. Mr. Cumming says they
nderlie the limestone which rests conformably upon them. I have
earched carefully the various points where they appear at Langness,
n the banks of the river Santon, at Cushnahavin, and in Derby-
aven bay, and nowhere can I find evidence to support this state-
ient. The sections exposed are nearly all on the coast, and are
iuch obscured by the overgrowth of sea-weed, and by discoloura-
ion, etc., etc. There was only one place where the sequence of the
eds seemed to me unmistakable, and that was in the beds lying
lmost horizontally between high and low water mark in Derby-
aven bay, and there, certainly, as far as I could make out, the grey
nd dark coloured limestone was overlain by beds of an ochreous
olour, still unmistakable limestone, and in every respect bedded
ike the grey limestone just mentioned; above this red-coloured lime-
tone again lay the beds of red conglomerate. Nowhere, as I have
aid, could I see any evidences that the conglomerate was overlain
y the limestone, nor do I believe, after having tested the position
arefully, that such a succession of the beds can be seen anywhere in
his part of the island. On the contrary, north of the Santon
rook, where, by the violence of the great discharge of trap, the
eds are torn and twisted in an extraordinary fashion, a bed of
imestone has been thrown up on end, and its lower surface has been
ared, and we can examine very easily both its upper and lower

surface. The latter rests immediately on the schist, and I have a number of specimens broken off from the very point of contact, where unmistakable schist is immediately in contact with unmistakable limestone, and nothing intervenes between them, the beds at the same time resting apparently conformably one upon the other. This may be seen at Cushnahavin, a few yards north of the estuary of the Santon brook; a few yards to the south, as I have said, the purple schists may be also seen in immediate contact with the limestone, showing that no Devonian beds intervened.

Fourthly, as to the red colour of the beds. This is undoubted, but, as I believe, it has nothing to do with the beds being Devonian. At the mouth of the Santon brook may be seen a sight which Mr. Cumming rightly considers as one of the most interesting which a geologist can see anywhere. The twisted and contorted schists gradually change colour, and from being of a blue, and grey colour, become striped with red bands, which are occasionally a foot and a foot and a half in width, and eventually the whole rock, without changing its character, assumes a beautiful purple colour. The brook passes right through these purple schists; some ten or fifteen yards to the south of the brook the schists lie directly against and in contact with the great beds of Mountain Limestone. At the point of contact, and some distance beyond, the limestone is coloured of a russet colour by iron. There are no interposed beds of red conglomerate, but the schists and the limestone are both of them stained red with iron for some distance from the point of junction. Further, I was told by a neighbouring farmer that a shaft had been pierced into the limestone at the point of contact in search of iron-ore, which had been found there.

Peel, which I have not seen, and my arguments only apply to the beds in the south of the island. Having shown that the red beds are not Devonian, I hope in another communication to show what they really are.

REVIEWS.

I.—A CATALOGUE OF BRITISH FOSSIL CRUSTACEA, WITH THEIR SYNONYMS AND THE RANGE IN TIME OF EACH GENUS AND ORDER. By HENRY WOODWARD, F.R.S., F.G.S., of the Department of Geology, British Museum. 8vo. pp. 168. (London: Printed by order of the Trustees, April, 1877.)

THE want of a Catalogue of British Fossil Crustacea, in which all the synonyms should be given, has long been felt. The present task was commenced some years since; but, owing to the unsatisfactory state of one group, the Bivalved Entomostraca, which greatly needed revision, the work was for some time laid aside by its author for other and more pressing occupations.

Thanks to the labours of Messrs. Brady, Crosskey, and Robertson, whose Monograph on the British Fossil Post-Tertiary Entomostraca forms quite a volume of itself in the Monographs of the Palæontographical Society for 1874, this portion of the work has now been very carefully worked out, and when combined with the long labours of Prof. T. Rupert Jones, F.R.S., amongst the older forms, leaves little more to be desired in the completion of this group.

Some idea may be formed of the progress of palæontological work in this country from the fact that when Prof. Morris's Catalogue of British Fossils was published in 1854, he recorded 81 genera and 306 species of Fossil Crustacea only.

The present Catalogue contains a record of 197 genera, and 1051 species and varieties found fossil in Britain; so that, since 1854, 116 new genera, and 745 new species and varieties of Fossil Crustacea have been figured and described in Britain.

With the exception of one doubtful organism (the *Eozoon Canadense*) not met with in the oldest known British Sedimentary rocks, the fossil representatives of the class CRUSTACEA take rank in antiquity amongst the earliest known organic remains.

From the recently discovered *Pre*-Cambrian rocks of St. David's, Pembrokeshire (the "Dimetian" and "Pebidian" formations), no organic remains of any kind have been obtained; the Lower Cambrian series, however, have yielded to the labours of Mr. Henry Hicks, F.G.S., and others, remains of MOLLUSCOIDA, ANNELIDA, and CRUSTACEA.

Of the thirteen Orders enumerated in the subjoined Table (p. 416), *two only* (printed in *Italics*) are extinct, namely the TRILOBITA and EURYPTERIDA, and three are not represented in a fossil state, viz. the CLADOCERA, the COPEPODA, and the RHIZOCEPHALA.

The small Table is intended to show at a glance the earliest appearance in time (so far as we have been enabled to ascertain it) of each order, and its recurrence in each successive formation.

	Decapoda Brachyura.	Decapoda Anomura.	Decapoda Macrura.	Stomapoda.	Isopoda.	Trilobita (extinct).	Amphipoda.	Xiphosura.	Eurypterida (extinct).	Phyllopoda.	Ostracoda.	Balanidæ.	Lepadidæ.
Post-Tertiary.........	x	x	x	x	x	.....	x	x	.....	x	x	x	x
Tertiary	x	x	x	x	x	.....	x	x	.....	x	x	x	x
Cretaceous	x	x	x	x	x	.....	.....	.....	—	x	x	x	x
Jurassic	x	.....	x	x	x	.....	x	x	.....	x	x	—	x
Triassic	.....	.....	x	.....	.....	.....	.....	—	.....	x	x		
Permian..................	.....	.....	.....	.....	.....	.....	x	.....	—	x	x		
Carboniferous	.....	.....	x	x	x	x	x	x	x	x	x		
Old Red Sandstone	.....	.....	.....	.....	x	x	.....	.....	x	x	x		
Upper Silurian	.....	.....	.....	.....	.....	x	x	x	x	x	x	—	x
Lower Silurian	.....	.....	.....	.....	.....	x	.....	.....	.....	x	x		
Cambrian	.....	.....	.....	.....	.....	x	.....	.....	.....	x	x		
Pre-Cambrian													

Brachyura.—The oldest known Crab is the *Palæinachus longipes*, H. Woodw., from the Forest Marble (Great Oolite), Wilts. The Crabs are well represented from the Jurassic period to the present day, when they attain their maximum development within the warm, temperate, and subtropical latitudes, where land, freshwater, and marine specimens abound.

Anomura.—The Anomura embrace forms of Decapoda, both related to the Brachyura (*e.g. Dromia, Porcellana, Dorippe*, etc.) and to the Macrura (*e.g. Pagurus, Galathea, Munida*). Their earliest appearance is in the Cretaceous period. Numerous species of *land* and marine Anomura are found within the tropics, and the marine species occur very widely distributed in the colder seas of the globe.

Macrura.—Of this division of the Decapoda a single species, the *Anthrapalæmon Grossartii*, occurs in the Coal-measures, and is well represented from the Trias to the present day. There are abundant freshwater and marine, but *no land*-dwelling Macrura.

Stomapoda.—One species (the *Pygocephalus Huxleyi*, H. Woodw.) from the Coal-measures probably is referable to this division. True *Squillas* and *Mysis*-like Crustaceans occur in the Jurassic rocks. They are most abundant in our modern seas.

Isopoda.—The remains of a single species of Isopod, *Præarcturus gigas*, H. Woodw., have been obtained from the Old Red Sandstone of Herefordshire, and other representatives occur in the Carboniferous and Secondary rocks. The Isopoda are most widely distributed over land and sea to-day—terrestrial, freshwater, and marine species abound.

Trilobita.—This extinct Order ranges from the Lower Cambrian to the Carboniferous Series, more than 300 British species being described, and in Bohemia 350 species have been named and figured by Barrande alone. The great *Paradoxides Davidis* measures nearly two feet in length. As this group ascends in time, we find those extravagantly ornamented and spinose forms, such as *Paradoxides* and *Acidaspis*, disappear; and only three genera survive in the Carboniferous, small in size, and very regular and neat in form, especially the genus *Griffithides*.

Amphipoda.—The Amphipoda has one representative in the Upper Silurian (the *Necrogammarus Salweyi*, H. Woodw.); it is represented by *Gampsonyx* in the Coal of Rhenish Prussia; and by the genus *Prosoponiscus* in the Permian of Durham. Other (Secondary) species occur in Bavaria, etc. The living genera of Amphipoda are abundant both in marine and freshwater, and some species are even terrestrial in their habits.

Xiphosura.—The earliest representative of the King-Crabs known is the *Neolimulus falcatus*, H. Woodw., from the Upper Silurian of Lanarkshire; several species are met with in the Coal-measures, and are very widely distributed. The genus is represented largely in the Oolite of Bavaria, and is also found living to-day in both the Old and New World.

Eurypterida.—The Eurypterida, like the Trilobita, are an extinct order. They were represented in Devonian and Silurian times by genera, which attained a length of from 5 to 6 feet. They are nearly related to the King-Crabs in structure, but differed in their development as do the Lobsters from the Crabs at the present day: the Xiphosura representing the Brachyura, and the Eurypterida the Macrura.

Phyllopoda.—The Phyllopoda are represented from the Middle Cambrian to the Tertiary period by many genera. Large extinct forms, closely resembling the little modern *Nebalia bipes*, were abundant in the Upper Silurian of Ludlow and Lanark. They are represented to-day by species in freshwater, brackish water, salt water, and highly saline salterns and lakes.

Ostracoda.—The Bivalved Entomostraca included in this order are largely represented throughout the entire series of stratified rocks, from the Lower Cambrian to the present day; they are equally well represented in a recent state. They not unfrequently (as in the *Cypris* shales of the Wealden) make up entire strata with their accumulated bivalved carapaces.

Cirripedia. (*a.*) Balanidæ.—The oldest fossil sessile Cirripede is the *Pyrgoma cretacea*, H. Woodw., from the Upper Chalk of Norwich.

(*b.*) Lepadidæ.—The oldest known pedunculated Cirripede is the *Turrilepas Wrightii*, H. Woodw., from the Upper Silurian of Dudley. None have been met with lower than the Lias except *Turrilepas;* but from the Lias upwards, pedunculated forms are well represented.

The group is abundant and cosmopolitan in all the seas of the world, parasitic on all objects, living and dead.

The subjoined Table gives the number of genera, species, and varieties belonging to each order, and suborder in the class Crustacea.

CLASS CRUSTACEA.

	Genera.	Species.	Var.
Subclass I. THORACIPODA, H. Woodw. (or MALACOSTRACA).			
Legion 1. PODOPHTHALMIA.			
Order 1. **Decapoda.**			
Suborder (*a*) BRACHYURA	27	41	
,, (*b*) ANOMURA	2	3	
,, (*c*) MACRURA	22	52	
Order 2. **Stomapoda**	2	4	
Legion 2. EDRIOPHTHALMIA.			
Order 3. **Isopoda**	3	3	
,, 4. *TRILOBITA*	51	304	18
,, 5. **Amphipoda**	1	1	
Subclass II. GNATHOPODA, H. Woodw. (or ENTOMOSTRACA).			
Legion 3. MEROSTOMATA.			
Order 6. **Xiphosura,** and CYCLUS (?)	4	16	
,, 7. *EURYPTERIDA*	5	36	4
Legion 4. BRANCHIOPODA.			
Order 8. **Phyllopoda**	12	55	6
,, 9. **Cladocera.**			
Legion 5. LOPHYROPODA.			
Order 10. **Ostracoda**	55	413	41
,, 11. **Copepoda.**			
Legion 6. ANCHORACEPHALA.			
Order 12. **Rhizocephala.**			
,, 13. **Cirripedia.**			
,, (*a*) BALANIDÆ	5	18	
,, (*b*) LEPADIDÆ	4	29	3
Crustacean "Teeth," Eggs, and "Tracks"	4	4	
	197	979	72

II.—1. HISTORY OF AUSTRALIAN TERTIARY GEOLOGY. By the Rev is the same break between the Secondary and Tertiary series. Mr. Woods is of opinion that the weight of evidence is against the theory advanced by some that any part of the continent has remained dry land since the Mesozoic period.

Mr. R. M. Johnston's paper deals with the stratigraphical order of the Table Cape Tertiary series. The surrounding country has been subjected to a large amount of denudation, a capping of basalt and basaltic tuff, 80 feet thick, acting as the protecting medium in the immediate vicinity of the Cape. Beneath this cap is a series of beds of white and grey calcareous sandstone, termed by the author the "*Turritella* Group" from the prevalence of *T. Warburtonii*, Tenison-Woods. The deposit next in order of succession below the "Turritella Group" consists of an "irregular agglomeration of shells, bound up in a matrix of ferruginous-looking mud," and is called the "*Crassatella* bed." The fauna of both groups is a copious one, and they are respectively characterized more by the prevalence of certain forms in each, and the gradual diminution or increase of these, as the case may be, as we pass from one series to the other, than by the restriction of species to each bed. All that can be said is that the Turritella Group and Crassatella bed were accumulated under somewhat different conditions to one another. This marine deposit rests upon a highly indurated conglomerate floor, which probably corresponds to a conglomerate described by Mr. Gould on the Dial Range, as of Silurian age. At the Table Cape this conglomerate appears to rest unconformably on slate rock.

The species obtained by Mr. Johnston from the Tertiary beds of Table Cape, 150 in number, were examined by the Rev. Mr. Woods, and the new species described in the third paper above cited. Eighty of these were found to be new, of which, 10 per cent. are existing forms, and appear to indicate the Table Cape beds as a deposit of the Laminarian zone. The Foraminifera are abundant, and amongst the Corals are the only true reef-builders met with in the Australian Tertiaries. The Brachiopoda are also abundant, and the Echinodermata numerous, presenting some new forms, whilst on the other hand the Polyzoa are scarce, a marked contrast to similar beds in South Australia. Eliminating those fossils peculiar to the Table Cape beds, the majority are identical with those of the S. Australian so-called Miocene, there being a greater resemblance between the two deposits on each side Bass's Straits, than between the existing Molluscan faunas of the two coasts. The new species described by Mr. Woods are divided as follows:—Gasteropoda, 48 or 49; Lamellibranchiata, 9; Polyzoa, 1; Corals, 2; and by Mr. Johnston, Echinodermata, 1.

The Polyzoon described is both a new genus and species—*Buskia*, (*B. typica*, Tenison-Woods). We would merely point out that the term *Buskia* has already been made use of in a generic sense by the late Mr. Alder for a recent Zoophyte, which he named *Buskia nitens*.[1]

R. E., Jun.

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[1] Catalogue of the Zoophytes of Northumberland and Durham, Trans. Tyneside Nat. Field Club, vol. iii. p. 156.

REPORTS AND PROCEEDINGS.

I.—Royal Geological Society of Ireland.—March 16, 1877.

"On the Nature and Origin of the Beds of Chert in the Upper Carboniferous Limestones of Ireland." By Prof. Edward Hull, M.A., F.R.S., Director Geol. Survey of Ireland. With "Chemical Notes," by E. T. Hardman, F.C.S., Geol. Survey of Ireland.

After reviewing what had been published by previous authors on the origin of chert-beds, and showing that much remained to be done in this department of petrology, the author proceeded to describe the geological position of the principal cherty zone of the Carboniferous Limestone of Ireland, showing that, while bands of chert occur at intervals throughout this formation, the highest beds immediately under "The Yoredale Shales" are especially rich in chert, and are frequently entirely replaced by this mineral. In these beds coralline, crinoidal, and other marine forms were frequently to be recognized by the naked eye. Thin slices for microscopic examination, taken from various localities, extending from Sligo to Carlow, also showed that even the most dense and compact masses of chert exhibit, under favourable circumstances, forms belonging to those of marine animals —such as corals, crinoids, foraminifera, and occasionally molluscs, animals which build their shells or skeletons of carbonate of lime rather than of silica. The siliceous paste in which these forms are inclosed was found to be in a gelatinous state, and the forms were only to be distinguished by difference in depth of shade from the paste, the shells or skeletons having disappeared. The chemical analyses of these specimens by Mr. E. T. Hardman, F.C.S., tended to show that the chert-beds contain various proportions of carbonate ation would take place, analogous to that described by Prof. Dr. P. Martin Duncan, F.R.S., as having occurred in West Indian Corals.

The paper was accompanied by chemical analyses and photographic figures of some of the thin slices, slightly magnified.

II.—British Association, Plymouth, August 16th, 1877.—Section C. Address to the Geological Section. By W. Pengelly, F.R.S., F.G.S., President of the Section.

When, as long ago as 1841, the British Association made its only previous visit to Plymouth, some of us, now amongst its oldest members, thought ourselves too young to take any part in its proceedings. If the effects of that meeting are still traceable in this district, it will be admitted, of course, that the seed then sown was of excellent quality and that it fell on good soil. Be this as it may, the hope may be cherished that thirty-six years will not again be allowed to elapse between two consecutive visits to the capital of the two south-western counties.

One effect of this wide hiatus is the loss of almost all the human links whose presence on this occasion would have pleasantly connected the present with the past. A glance at the lists of Trustees and the General, Sectional, and Local officers in 1841 will show that the presence of scarcely one of them can be hoped for on this occasion; and there is but little probability that any of those who prepared Reports or Papers for the last Plymouth Meeting will have done so for that which is now assembled.

Nor are these the only changes. In 1841 Section C embraced, as at the beginning, the Geographers as well as the Geologists; but ten years later the Geographers were detached, whether to find room for themselves, or to make room for the students of an older geography, it is not necessary to inquire.

Some years afterwards came an innovation which, until entering on the preparation of this address, I always regarded as a decided improvement. The first Presidential Address to this Section was delivered at Leeds in 1858 by the late Mr. Hopkins, so well known to geologists for his able application of his great mathematical powers to sundry important problems in their science; and from that time to the present, with the exception of the Meetings of 1860 and 1870 only, the President of this Section has delivered an address.

None of the local geological papers read in 1841 appear to have attracted so much attention as those on Lithodomous Perforations, Raised Beaches, Submerged Forests, and Caverns (see Athenæum for 7th to 28th of August, 1841); and, as an effort to connect the present with the past, I have decided on taking up one of these threads, and devoting the remarks I have now to offer to the History of Cavern-Exploration in Devonshire. I am not unmindful that there were giants in those days; and no one can deplore more than I do our loss of Buckland and De la Beche, amongst many others; nor can I forget the enormous strides opinion has made since 1841, when, in this Section, Dr. Buckland "contended that human remains had never been found under such circumstances as to prove their contemporaneous existence with the hyænas and bears of the Caverns," and added that "in Kent's Hole the Celtic knives . . . . . were found in holes *dug by art*, and which had disturbed the floor of the cave and the bones below it" (Athenæum, 14th Aug. 1841, p. 626). This scepticism, however, did the good service of inducing cavern explorers to conduct their researches with an accuracy which should place their results, whatever they might prove to be, amongst the undoubted additions to human knowledge.

The principal Caverns in South Devon occur in the limestone districts of Plymouth, Yealmpton, Brixham, Torquay, Buckfastleigh, and Chudleigh; but as those in the last two localities have yielded nothing of importance to the Anthropologist or the Palæontologist, they will not be further noticed on this occasion. In dealing with the others it seems most simple to follow mainly the order of chronology; that is to say, to commence with the Cavern which first caught scientific attention, and, having finished all that the time at my disposal will allow me to say about it, but not before, to proceed to the next, in the order thus defined; and so on through the series.

Oreston Caverns.—When Mr. Whidbey engaged to superintend the construction of the Plymouth Breakwater, Sir Joseph Banks, President of the Royal Society, requested him to examine narrowly any caverns he might meet with in the limestone-rock to be quarried at Oreston, near the mouth of the river Plym, not more than two miles from the room in which we are assembled, and have the bones or any other fossil remains that were met with carefully preserved (see Phil. Trans. 1817, pp. 176–182). This request was cheerfully complied with, and Mr. Whidbey had the pleasure of discovering bone-caves in November 1816, November 1820, August and Nov. 1822, and of sending the remains found in them to the Royal Society.

It is, perhaps, worthy of remark that, though Cavern-researches received a great impulse from the discoveries in Kirkdale, Yorkshire, and especially from Dr. Buckland's well-known and graphic descriptions of them, such researches had originated many years before. The request by Sir Joseph Banks was made at least as early as 1812 (see Trans. Devon. Assoc. v. pp. 252, 253), and a paper on the Oreston discoveries was read to the Royal Society in February 1817, whereas the Kirkdale Cavern was not discovered until 1821. British Cave-hunting appears to have been a science of Devonshire birth.

The Oreston Caverns soon attracted a considerable number of able observers; they were visited in 1822 by Dr. Buckland and Mr. Warburton; and in a comparatively short time became the theme of a somewhat voluminous literature. Nothing of importance, however, seems to have been met with from 1822 until 1858, when another cavern, containing a large number of bones, was broken into. Unfortunately, there was no one at hand to superintend the exhumation of the specimens; the work was left entirely to the common workmen, and was badly done; many of the remains were dispersed beyond recovery; the matrix in which they were buried was never adequately examined; and we are utterly ignorant, and must for ever remain so, as to whether they did or did not contain indications of human existence. I visited the spot from time to time, and bought up everything to be met with; but other scientific work in another part of the county occupied me too closely to allow more than an occasional visit. The greater part of the specimens I secured were lodged in the British Museum, where they seem to have been forgotten, whilst a few remain in my private collection.

Some difference of opinion has existed respecting the character of the successive caverns, and much mystery has been imported into the question of the introduction of their contents. Mr. Whidbey, it is said, "saw no possibility of the cavern of 1816 having had any external communication through the rock in which it was inclosed" (Phil. Trans. 1817, pp. 176-182); but Dr. Buckland was of opinion that they were all at first fissures open at the top, and "that the openings had been long filled up with rubbish, mud, stalactite, or fragments of rocks cemented, as sometimes happens, into a breccia as solid as the original rock, and overgrown with grass" (Phil. Trans. 1822, pp. 171-240).

The conclusion I arrived at, after studying so much of the roof of the cavern of 1858 as remained intact, was that Dr. Buckland's opinion was fully borne out by the facts; that, in short, the Oreston caverns were *Fissure Caverns*, not *Tunnel Caverns.*

The Cavern of 1858 was an almost vertical fissure, extending a length of about 90 feet from N.N.E. to S.S.W. It commenced at about 8 feet below the surface of the plateau, continued thence to the base of the cliff, but how much further was not known, and its ascertained height was about 52 feet. It was 2 feet wide at top, whence it gradually widened to 10 feet at bottom. The roof, judging from that part which had not been destroyed, was a mass of limestone-breccia, made up of large angular fragments, cemented with carbonate of lime, and requiring to be blasted as much as ordinary limestone. The Cavern was completely filled with deposits of various kinds.

The uppermost 8 feet consisted of loose angular pieces of limestone, none of which exceeded 10lb. in weight, mixed with a comparatively small amount of such sand as is common in dolomitized limestone districts, but without a trace of stalagmite or fossil of any kind. The 32 feet next below were occupied with similar materials, with the addition of a considerable quantity of tough, dark, unctuous clay. Between this mass and the outer wall of the cavern was a nearly vertical plate of stalagmite, usually about 2 feet thick, and containing, at by no means wide intervals, firmly cemented masses of breccia identical in composition with the adjacent bed just mentioned. The bones the caverns yielded were all found within these 32 feet; and were met with equally in the loose and the coherent breccia, as well as in the stalagmite. A somewhat considerable number of ellipsoidal balls of clay, from 1·5 to 2·5 inches in greatest diameter, occurred in the clay of this bone-bed, but not elsewhere. Still lower was a mass of dark, tough, unctuous clay, containing a very few, small, angular stones, but otherwise perfectly homogeneous, and known to be 12 feet deep, but how much more was undetermined.

The osseous remains found at Oreston prior to 1858 have been described by Sir E. Home, Mr. Clift, Dr. Buckland, Professor Owen, Mr. Busk, and others. The animals represented were *Ursus priscus*, *U. spelæus*, Weasel (?), Wolf, Fox, Cave Hyæna, Cave Lion, *Rhinoceros leptorhinus*, *Equus fossilis*, *E. plicidens*, *Asinus fossilis*, *Bison minor*, *Bos longifrons*, and, according to the late Mr. Bellamy, Mammoth and Hippopotamus (see Nat. Hist. of S. Devon, 1839, p. 82). With regard to Hippopotamus, I can only say that I have never met with satisfactory evidence of its occurrence in Devonshire; but the Mammoth was certainly found at Oreston in 1858; and, unless I am greatly in error, remains of *Rhinoceros tichorhinus* were also met with then, and lodged by me in the British Museum. It may be added that the skull and other relics of Hog were exhumed on that occasion, and now belong to my collection. There was nothing to suggest that the cavern had been the home of the Hyæna; and whilst I fully accept Dr. Buckland's opinion that the animals had fallen into the open fissures and there perished, and that the remains had subsequently been washed thence into the lower vaultings (Reliq. Dil. 2nd ed. 1834, p. 78), I venture to add that some of the animals may have retired thither to die; a few may have been dragged or pursued there by beasts of prey; whilst rains, such as are not quite unknown in Devonshire in the present day, probably washed in some of the bones of such as died near at hand on the adjacent plateau. Nothing appears to have been met with suggestive of human visits.

Kent's Hole.—About a mile due east from Torquay harbour and half a mile north from Torbay, there is a small wooded limestone hill, the eastern side of which is, for the uppermost 30 feet, a vertical cliff, having at its base, and 54 feet apart, two apertures leading into one and the same vast cavity in the interior of the hill, and known as Kent's Hole or Cavern. These openings are about 200 feet above mean sea-level, and from them the hill slopes rapidly to the valley at its foot, at a level of from 60 to 70 feet below.

There seems to be neither record nor tradition of the discovery of the Cavern. Richardson, in the 8th edition of 'A Tour through the Island of Great Britain,' published in 1778, speaks of it as "perhaps the greatest natural curiosity" in the county; its name occurs on a map dated 1769; it is mentioned in a lease dated 1659; visitors cut their names and dates on the stalagmite from 1571 down to the present century; judging from numerous objects found on the floor, it was visited by man through mediæval back to pre-Roman times; and, unless the facts exhumed by explorers have been misinterpreted, it was a human home during the era of the Mammoth and his contemporaries.

In 1824, Mr. Northmore, of Cleve, near Exeter, was led to make a few diggings in the Cavern, and was the first to find fossil bones there. He was soon followed by Mr. (now Sir) W. C. Trevelyan, who not only found bones, but had a plate of them engraved. In 1825, the Rev. J. MacEnery, an Irish Roman Catholic priest residing in the family of Mr. Cary, of Tor Abbey, Torquay, first visited the Cavern, when he, too, found teeth and bones, of which he published a plate. Soon after, he made another visit, accompanied by Dr. Buckland, when he had the good fortune to discover a flint implement; the first instance, he tells us, of such a relic being noticed in any cavern (see Trans. Devon Assoc. iii. p. 441). Before the close of 1825, he commenced a series of more or less systematic diggings, and continued them until, and perhaps after, the summer of 1829 (ibid. p. 295). Preparations appear to have been made to publish the results of his labours; a prospectus was issued, numerous plates were lithographed, it was generally believed that the MS. was almost ready, and the only thing needed was a list of subscribers sufficient to justify publication, when, alas! on the 18th February, 1841, before the printer had received any "copy," before even the world of Science had accepted his anthropological discoveries, before the value of his labours were known to more than a very few, Mr. MacEnery died at Torquay.

After his decease his MS. could not be discovered, and its loss was duly deplored. Nevertheless, it was found after several years, and, having undergone varieties of fortune, became the property of Mr. Vivian, of Torquay, who, having published portions of it in 1859, presented it in 1867 to the Torquay Natural History Society, whose property it still remains. In 1869, I had the pleasure of printing the whole, in the 'Transactions of the Devonshire Association.'

Whilst Mr. MacEnery was conducting his researches, a few independent diggings, on a less extensive scale, were undertaken by other gentlemen. The principal of these was Mr. Godwin-Austen, the well-known geologist, whose papers fully bore out all that MacEnery had stated (see Trans. Geol. Soc. Lond. 2nd series, vi. p. 446). In 1846, a sub-committee of the Torquay Natural History Society undertook the careful exploration of very small parts of the Cavern, and their Report was entirely confirmatory of the statements of their predecessors—that undoubted flint implements did occur, mixed with the remains of extinct mammals, in the cave-earth, beneath a thick floor of stalagmite. The sceptical position of the authorities in geological science remained unaffected, however, until 1858, when the discovery and systematic exploration of a comparatively small virgin cavern on Windmill Hill, at Brixham, led to a sudden and complete revolution; for it was seen that whatever were the facts elsewhere, there had undoubtedly been found at Brixham flint implements commingled with the remains of the Mammoth and his companions, and in such a way as to render it impossible to doubt that Man occupied Devonshire before the extinction of the cave mammals.

Under the feeling that the statements made by MacEnery and his followers respecting Kent's Hole were perhaps, after all, to be accepted as verities, the British Association, in 1864, appointed a Committee to make a complete, systematic, and accurate exploration of the Cavern, in which it was known that very extensive portions remained entirely intact. This Committee commenced its labours on 28th March, 1865; it has been reappointed, year after year, with sufficient grants of money, up to the present time; the work has gone on continuously throughout the entire thirteen years; and the result has been, not only a complete confirmation of Mr. MacEnery's statements, but the discovery of far older deposits than he suspected—deposits implying great changes of, at least, local geographical conditions; changes in the fauna of the district; and yielding evidence of men more ancient and far ruder than even those who made the oldest flint tools found in Kent's Hole prior to the appointment of the Committee.

The Cavern consists of a series of chambers and passages, which resolve themselves into two main *Divisions*, extending from nearly north to south in parallel lines, but passing into each other near their extremities, and throwing off branches, occasionally of considerable size.

The successive deposits, in descending order, were:—

1st, or uppermost. Fragments and blocks of limestone from an ounce to upwards of 100 tons weight each, which had fallen from the roof from time to time, and were in some instances cemented with carbonate of lime.

2nd. Beneath and between these blocks lay a dark-coloured mud or mould, consisting largely of decayed leaves and other vegetable matter. It was from three to twelve inches thick, and known as the *Black Mould*. This occupied the entire Eastern Division, with the exception of a small chamber in its south-western end only, but was not found in the other, the remoter, parts of the Cavern.

3rd. Under this was a Stalagmitic Floor, commonly of granular texture and frequently laminated, from less than an inch to fully five feet in thickness, and termed the *Granular Stalagmite*.

4th. An almost black layer, about four inches thick, composed mainly of small fragments of charred wood, and distinguished as the *Black Band*, occupied an area of about 100 square feet, immediately under the Granular Stalagmite, and, at the nearest point, not more than 32 feet from one of the entrances to the Cavern. Nothing of the kind has occurred elsewhere.

5th. Immediately under the Granular Stalagmite and the Black Band lay a light red clay, containing usually about 50 per cent. of small angular fragments of limestone, and somewhat numerous blocks of the same rock as large as those lying on the Black Mould. In this deposit, known as the *Cave-earth*, many of the stones and bones were, at all depths, invested with thin stalagmitic films. The Cave-earth was of unknown depth near the entrances, where its base had never been reached; but in the remoter parts of the Cavern it did not usually exceed a foot, and in a few localities it "thinned out" entirely.

6th. Beneath the Cave-earth there was usually found a Floor of Stalagmite having a crystalline texture, and termed on that account the *Crystalline Stalagmite*. It was commonly thicker than the Granular Floor, and in one instance but little short of 12 feet.

7th. Below the whole, occurred, so far as is at present known, the oldest of the Cavern deposits. It was composed of subangular and rounded pieces of dark red grit, imbedded in a sandy paste of the same colour. Small angular fragments of limestone, and investing films of stalagmite, both prevalent in the Cave-earth, were extremely rare. Large blocks of limestone were occasionally met with; and the deposit, to which the name of *Breccia* was given, was of a depth exceeding that to which the exploration has yet been carried.

Except in a very few small branches, the bottom of the Cavern has nowhere been reached. In the cases in which there was no Cave-earth, the Granular Stalagmite rested immediately on the Crystalline; and where the Crystalline Stalagmite was not present, the Cave-earth and Breccia were in direct contact. Large isolated masses of the Crystalline Stalagmite, as well as concreted lumps of the Breccia, were occasionally met with in the Cave-earth, thus showing that the older deposits had, in portions of the Cavern, been partially broken up, dislodged, and redeposited. No instance was met with of the incorporation in a lower bed of fragments derived from an upper one. In short, wherever all the deposits were found in one and the same vertical section, the order of superposition was clear and invariable; and elsewhere the succession, though defective, was never transgressed.

Excepting the overlying blocks of limestone, of course, all the deposits contained remains of animals, which, however, were not abundant in the Stalagmites.

The Black Mould, the uppermost bed, yielded teeth and bones of Man, Dog, Fox, Badger, Brown Bear, *Bos longifrons*, Roedeer, Sheep, Goat, Pig, Hare, Rabbit, and Seal—species still existing, and almost all of them in Devonshire. This has been called the *Ovine* bed, the remains of Sheep being restricted to it. In it were also found numerous flint flakes and "strike-lights;" stone spindle whorls; fragments of curvilinear pieces of slate; amber beads; bone tools, including awls, chisels, and combs; bronze articles, such as rings, a fibula, a spoon, a spear-head, a socketed celt, and a pin; pieces of smelted copper; and a great number and variety of potsherds, including fragments of Samian ware.

The Granular Stalagmite, Black Band, and Cave-earth, taken together as belonging to one and the same biological period, may be termed the *Hyænine* beds, the Cave Hyæna being their most prevalent species and found in them alone. So far as they have been identified, the remains belong to the Cave Hyæna, *Equus caballus*, *Rhinoceros tichorhinus*, Gigantic Irish Deer, *Bos primigenius*, *Bison priscus*, Red Deer, Mammoth, Badger, Cave Bear, Grizzly Bear, Brown Bear, Cave Lion, Wolf, Fox, Reindeer, Beaver, Glutton, *Machairodus latidens*, and Man—the last being a part of a jaw with teeth, in the Granular Stalagmite. In the same beds were found unpolished *ovate* and *lanceolate* implements made from *flakes*, not *nodules*, of flint and chert; flint flakes, chips, and "cores;" "whetstones;" a "hammer-stone;" "dead" shells of *Pecten*; bits of charcoal; and bone tools, including a needle or bodkin having a well-formed eye, a pin, an awl, three harpoons, and a perforated tooth of Badger. The artificial objects, of both bone and stone, were found at all depths in each of the Hyænine beds, but were much more numerous below the Stalagmite than in it.

The relics found in the Crystalline Stalagmite and the Breccia, in some places extremely abundant, were almost exclusively those of Bear, the only exceptions being a very few remains of Cave Lion and Fox. Hence these have been termed the *Ursine* beds. It will be remembered that teeth and bones of Bear were also met with in both the Hyænine and the Ovine beds; and it should be understood that this biological classification is intended to apply to Kent's Cavern only. The Ursine deposits, or rather the Breccia, the lowest of them, also yielded evidences of human existence; but they were exclusively tools made from *nodules*, not *flakes*, of flint and chert.

Ansty's-Cove Cavern.—About 3 furlongs from Kent's Hole towards N.N.E., near the top of the lofty cliff forming the northern boundary of the beautiful Ansty's Cove, Torquay, there is a cavern where, simultaneously with those in Kent's Cavern, Mr. MacEnery conducted some researches, of which he has left a brief account (see Trans. Devon. Assoc.

vi. pp. 61-69). I have visited it several times, but it seems to be frequently kept under lock and key, as a tool and powder house, by the workmen in a neighbouring quarry. It is a simple gallery, and, according to Mr. MacEnery, 63 feet long, from 3 to 9 feet high, and from 3 to 6 feet broad. Beneath some angular stones he found a stalagmitic floor 14 inches thick, and in the deposit below remains of Deer, Horse, Bear, Fox, Hyæna (?), Coprolites, a few marine and land shells, one white flint tool with fragments of others, a Roman coin, and potsherds.

In a letter to Sir W. C. Trevelyan, dated 16th December, 1825, Dr. Buckland states that Mr. MacEnery had found in this Cave "bones of all sorts of beasts, and also flint knives and Roman coins; in short, an open-mouthed cave, which has been inhabited by animals of all kinds, quadruped and biped, in all successive generations, and who have all left their exuviæ one upon another" (ibid. p. 69).

Yealm-Bridge Cavern.—About the year 1832 the workmen broke into a bone-cavern in Yealm-Bridge quarry, about one mile from the village of Yealmpton, and eight miles E.S.E. from Plymouth; and through their operations it was so nearly destroyed that but a small arm of it remained in 1835, when it was visited by Mr. J. C. Bellamy, who at once wrote an account of it, from which it appears that, so far as he could learn, the Cavern was about 30 feet below the original limestone surface, and was filled to within from 1 foot to 6 feet of the roof (see Nat. Hist. S. Devon, 1839, pp. 86-105). In the same year, but subsequently, it was examined by Captain (afterwards Colonel) Mudge, who states that there were originally three openings into the Cave, each about 12 feet above the river Yealm; that the deposits were, in descending order:—

1. Loam with bones and stones	3·5 feet.
2. Stiff whitish clay	2·5 „
3. Sand	6·0 „
4. Red clay	3·5 „
5. Argillaceous sand	6 to 18·0 „

and that, where they did not reach the roof, the deposits were covered with stalagmite.

On the authority of Mr. Clift and Professor Owen, Captain Mudge mentions relics of Elephant, Rhinoceros, Horse, Ox, Sheep, Hyæna, Dog, Wolf, Fox, Bear, Hare, and Water-Vole. The bones, and especially the teeth, of the Hyæna exceeded in number those of all the other animals, though remains of Horse and Ox were very abundant. Mr. Bellamy, whilst also mentioning all the foregoing forms, with the exception of Dog only, adds, Deer, Pig, Glutton, Weasel, and Mouse. He also speaks of the abundance of bones and teeth of Hyæna, but seems to regard the Fox as being almost as fully represented; and next in order he places Horse, Deer, Sheep, and Rabbit or Hare; whilst the relics of Elephant, Wolf, Bear, Pig, and Glutton are spoken of as very rare. The bones, he says, were found in the uppermost bed only. They were frequently mere fragments and splinters, some being undoubtedly gnawed, and all had become very adherent through loss of their animal matter. Those of cylindrical form were without their extremities; there was no approach to anatomical juxtaposition; and the remains belonged to individuals of all ages. Reliquiæ of Carnivorous animals greatly exceeded those of the Herbivora, and teeth were very abundant. Coprolites occurred at some depth below the stalagmite, in the upper bed, which also contained granitic and trappean pebbles, and lumps of breccia made up of fragments of rock, bones, pebbles, and stalagmite. The bones found prior to 1835 had been removed as rubbish, and some good specimens were recovered from materials employed in making a pathway. Nothing indicating the presence of man appears to have been found.

The Ash-Hole.—On the southern shore of Torbay, midway between the town of Brixham and Berry Head, and about half a mile from each, there is a cavern known as the *Ash-Hole.* It was partially explored, probably about, or soon after, the time Mr. MacEnery was engaged in Kent's Hole, by the late Rev. H. F. Lyte, who, unfortunately, does not appear to have left any account of the results. The earliest mention of this Cavern I have been able to find is a very brief one in Bellamy's 'Natural History of South Devon,' published in 1839 (p. 14). During the Plymouth Meeting in 1841, Mr. George Bartlett, a native of Brixham, who assisted Mr. Lyte, described to this Section the objects of interest the Ash-Hole had yielded (see Report Brit. Assoc. 1841, Trans. Sections, p. 61). So far as was then known, the Cave was 30 yards long and 6 yards broad. Below a recent accumulation, 4 feet deep, of loam and earth, with land and marine shells, bones of the domestic fowl and of Man, pottery, and various implements, lay a true Cave-earth, abounding in the remains of Elephant. Professor Owen, who identified, from this lower bed, relics of Badger, Polecat, Stoat, Water-vole, Rabbit, and Reindeer, remarks, that for the first good evidence of the Reindeer in this island he had been indebted to Mr. Bartlett, who stated that the remains were found in this Cavern (see Brit. Foss. Mam. 1846, pp. 109–110, 113–114, 116, 204, 212, 479–480). I have made numerous visits to the spot, which, when Mr. Lyte began his diggings, must have been a shaft-like fissure, accessible from the top only. A lateral opening, however, has been quarried into it; there is a narrow tunnel extending westward, in which the deposit is covered with a thick sheet of stalagmite, and where one is tempted to believe that a few weeks' labour might be well invested.

Brixham Cavern.—Early in 1858 an unsuspected Cavern was broken into by quarrymen at the north-western angle of Windmill Hill at Brixham, at a point 75 feet above the surface of the street almost vertically below, and 100 feet above mean tide. On being found to contain bones, a lease in it was secured for the Geological Society of London, who appointed a Committee of their members to undertake its exploration; funds were voted by the Royal Society, and supplemented by private subscriptions; the conduct of the investigation was entrusted to Mr. Prestwich and myself; and the work, under my superintendence, as the only resident member of the Committee, was begun in July 1858, and completed at midsummer 1859.

The Cavern, comprised within a space of 135 feet from north to south, and 100 from east to west, consisted of a series of tunnel galleries from 6 to 8 feet in greatest width, and 10 to 14 feet in height, with two small chambers and five external entrances.

The deposits, in descending order, were:—

1st, or uppermost. A Floor of Stalagmite, from a few inches to a foot thick, and continuous over very considerable areas, but not throughout the entire Cavern.

2nd. A mass of small angular fragments of limestone, cemented into a firm concrete with carbonate of lime, commenced at the principal entrance, which it completely filled, and whence it extended 34 feet only. It was termed the *First Bed.*

3rd. A layer of blackish matter, about 12 feet long, and nowhere more than a foot thick, occurred immediately beneath the First Bed, and was designated the *Second Bed.*

4th. A red, tenacious, clayey loam, containing a large number of angular and subangular fragments of limestone, varying from very small bits to blocks a ton in weight, made up the *Third Bed.* Pebbles of trap, quartz, and limestone were somewhat prevalent, whilst nodules of brown hematite of iron and blocks of stalagmite were occasionally met with in it. The usual depth of the bed was from 2 to 4 feet, but this was exceeded by 4 or 5 feet in two localities.

5th. The Third Bed lay immediately on an accumulation of pebbles of quartz, greenstone, grit, and limestone, mixed with small fragments of shale. The depth of this, known as the *Fourth* or *Gravel Bed*, was undetermined; for, excepting a few feet only, the limestone bottom was nowhere reached. There is abundant evidence that this bed, as well as a stalagmitic floor which had covered it, had been partially broken up and dislodged before the introduction of the Third Bed.

Organic remains were found in the Stalagmitic Floor and in each of the beds beneath it, with the exception of the Second only; but as 95 per cent. of the whole series occurred in the Third, this was not unfrequently termed the *Bone Bed*.

The Mammals represented in the Stalagmite were Bear, Reindeer, *Rhinoceros tichorhinus*, Mammoth, and Cave Lion.

The First Bed yielded Bear and Fox only.

In the Third Bed were found relics of Mammoth, *Rhinoceros tichorhinus*, Horse, *Bos primigenius*, *B. longifrons*, Red Deer, Reindeer, Roebuck, Cave Lion, Cave Hyæna, Cave Bear, Grizzly Bear, Brown Bear, Fox, Hare, Rabbit, *Lagomys spelæus*, Water-Vole, Shrew, Polecat, and Weasel.

The only remains met with in the Fourth Bed were those of Bear, Horse, Ox, and Mammoth.

The Human Industrial Remains exhumed in the Cavern were flint implements and a hammer-stone, and occurred in the Third and Fourth Beds only. The pieces of flint met with were 36 in number. Of these, 15 are held to show evidence of having been artificially worked, in 9 the workmanship is rude or doubtful, 4 have been mislaid, and the remainder are believed not to have been worked at all (see Phil. Trans. vol. 163, 1873, pp. 561, 562). Of the undoubted tools, 11 were found in the Third and 4 in the Fourth Bed. Two of those yielded by the Third Bed, found 40 feet apart, in two distinct but adjacent galleries, and one a month before the other, proved to be parts of one and the same *nodule*-tool; and I have little or no doubt that it had been washed out of the Fourth Bed and redeposited in the Third.

The Hammer-Stone was a quartzite pebble, found in the upper portion of the Fourth Bed, and bore distinct marks of the use to which it was applied.

Speaking of the discovery of the tools just mentioned, Mr. Prestwich said in 1859:—"It was not until I had myself witnessed the conditions under which flint implements had been found at Brixham, that I became fully impressed with the validity of the doubts thrown upon the previously prevailing opinions with respect to such remains in caves" (Phil. Trans. 1860, p 280); and according to Sir C. Lyell, writing in 1863:—"A sudden change of opinion was brought about in England respecting the probable coexistence, at a former period, of man and many extinct mammalia, in consequence of the results obtained from the careful exploration of a Cave at Brixham. . . . The new views very generally adopted by English geologists had no small influence on the subsequent progress of opinion in France" (Antiquity of Man, pp. 96, 97).

Bench Cavern.—Early in 1861 information was brought me that an ossiferous cave had just been discovered at Brixham, and, on visiting the spot, I found that, of the limestone quarries worked from time to time in the northern slope of Furzeham Hill, one known as Bench Quarry, about half a mile due north of Windmill Hill Cavern, and almost overhanging Torbay, had been abandoned in 1839, and that work had been recently resumed in it. It appeared that in 1839 the workmen had laid bare the greater part of a vertical dyke, composed of red clayey loam and angular pieces of limestone, forming a coherent wall-like mass, 27 feet high, 12 feet long, 2 feet in greatest thickness, and at its base 123 feet above sea-level. In the face of it lay several fine relics of the ordinary Cave Mammals, including an entire left lower jaw of *Hyæna spelæa* replete with teeth, but which had nevertheless failed to arrest the attention of the incurious workmen who exposed it, or of any one else.

Soon after the resumption of the work in 1861, the remnant of the outer wall of the fissure was removed, and caused the fall of an incoherent part of the dyke, which it had previously supported. Amongst the débris the workmen collected some hundreds of specimens of skulls, jaws, teeth, vertebræ, portions of antlers, and bones, but no indications of Man. Mr. Wolston, the proprietor, sent some of the choicest specimens to the British Museum, and submitted the remainder to Mr. Ayshford Sanford, F G.S., from whom I learn that the principal portion of them are relics of the Cave Hyæna, from the unborn whelp to very aged animals. With them, however, were remains of Bear, Reindeer, Ox, Hare, *Arvicola ratticeps*, *A. agrestis*, Wolf, Fox, and part of a single maxillary with teeth not distinguishable from those of *Canis isatis*. To this list I may add Rhinoceros, of which Mr. Wolston showed me at least one bone.

From the foregoing undesirably, but unavoidably, brief descriptions, it will be seen that the Devonshire Caverns, to which attention has been now directed, belong to two classes,—those of Oreston, the Ash-Hole, and Bench being *Fissure Caves;* whilst those of Yealm Bridge, Windmill Hill at Brixham, Kent's Hole, and Ansty's Cove are *Tunnel Caves*.

Windmill Hill and Kent's Hole Caverns have alone been satisfactorily explored; and besides them none have yielded evidence of the contemporaneity of Man with the extinct Cave Mammals.

Oreston is distinguished as the only known British Cavern which has yielded remains of *Rhinoceros leptorhinus* (Q. Journ. Geol. Soc. xxvi. p. 456).

Yealm Bridge Cavern, if we may accept Mr. Bellamy's identification in 1835, was the first in this country in which relics of Glutton were found (South Devon Monthly Museum, vi. pp. 218-223; see also Nat. Hist. S. Devon, 1839, p. 89). The same species was found in the Caves of Somerset and Glamorgan in 1865 (Pleist. Mam., Pal. Soc. pp. xxi, xxiii), in Kent's Hole in 1869 (Rep. Brit. Assoc. 1869, p. 207), and near Plas Heaton, in North Wales, 1870 (Quart. Journ. Geol. Soc. xxvii. p. 407).

Kent's Hole is the only known British Cave which has afforded remains of Beaver (Rep. Brit. Assoc. 1869, p. 208), and, up to the present year, the only one in which the remains of *Machairodus latidens* had been met with. Indeed, Mr. MacEnery's statement, that he found in 1826 five canines and one incisor of this species in the famous Torquay Cavern, was held by many palæontologists to be so very remarkable as, at least, to approach the incredible, until the Committee now engaged in the exploration exhumed, in 1872, an incisor of the same species, and thereby confirmed the announcement made by their distinguished predecessor nearly half a century before (Rep. Brit. Assoc. 1872, p. 46). In April last (1877) the Rev. J. M. Mello was able to inform the Geological Society of London that Derbyshire had shared with Devon the honour of having been a home of *Machairodus latidens*, he having found its canine tooth in Robin Hood Cave in that county, and that there, as in Kent's Hole, it was commingled with remains of the Cave Hyæna and his contemporaries (Abs. Proc. Geol. Soc. No. 334, pp. 3, 4).

The Ash Hole, as we have already seen, affords the first good evidence of a British Reindeer.

In looking at the published Reports on the two famous Torbay Caverns, it will be found that they have certain points of resemblance as well as some of dissimilarity :—

1st. The lowest known bed in each is composed of materials which, whilst they differ in the two cases, agree in being such as may have been furnished by the districts adjacent to the Cavern-hills respectively, but not by the hills themselves, and must have been deposited prior to the existing local geographical conditions. In each, this bed contained flint implements and relics of Bear, but in neither of them those of Hyæna. In short, the *Fourth Bed* of Windmill Hill Cavern, Brixham, and the *Breccia* of Kent's Hole, Torquay, are coeval, and belong to what I have called the *Ursine* period of the latter.

2nd. The beds just mentioned were in each Cavern sealed with a sheet of stalagmite, which was partially broken up, and considerable portions of the subjacent beds were dislodged before the introduction of the beds next deposited.

3rd. The Great Bone Bed, both at Brixham and Torquay, consisted of red clayey loam, with a large per-centage of angular fragments of limestone; and contained *flake* implements of flint and chert, inosculating with remains of Mammoth, the tichorhine Rhinoceros, and Hyæna. In fine, the *Cave-earth* of Kent's Hole and the *Third Bed* of Brixham Cavern correspond in their materials, in their osseous contents, and in their flint tools. They both belong to what I have named the *Hyænine* period of the Torquay Cave.

But, as already stated, there are points in which the two Caverns differ:—

1st. Whilst Kent's Hole was the home of Man, as well as of the contemporary Hyæna during the absences of the human occupant, there is no reason to suppose that either Man or any of the lower animals ever did more than make occasional visits to Brixham Cave. The latter contained no flint chips, no bone tools, no utilized *Pecten*-shells, no bits of charcoal, and no coprolites of Hyæna, all of which occurred in the Cave-earth of Kent's Hole.

2nd. In the Torquay Cave relics of Hyæna were much more abundant in the Cave-earth than those of any other species. Taking the teeth alone, of which vast numbers were found, those of the Hyæna amounted to about 30 per cent. of the entire series, notwithstanding the fact that, compared with most of the Cave-mammals, his jaws, when furnished completely, possess but few teeth. At Brixham, on the other hand, his relics of all kinds amounted to no more than 8·5 per cent. of all the osseous remains, whilst those of the Bear rose to 53 per cent.

3rd. The entrances of Brixham Cavern were completely filled up and its history suspended not later than the end of the Palæolithic era. Nothing occurred within it from the days when Devonshire was occupied by the Cave and Grizzly Bears, Reindeer, Rhinoceros, Cave Lion, Mammoth, and Man, whose best tools were unpolished flints, until the quarrymen broke into it early in A.D. 1851. Kent's Cavern, on the contrary, seems to have never been closed, never unvisited by Man, from the earliest Palæolithic times to our own, with the possible exception of the Neolithic era, of which it cannot be said to have yielded any certain evidence.

Though my *History of Cavern Exploration in Devonshire* is now completed, so far as the time at my disposal will allow, and so far as the materials are at present ripe for the historian, I venture to ask your further indulgence for a few brief moments whilst passing from the region of Fact to that of Inference.

That the Kent's-Hole men of the Hyænine period—to say nothing at present of their predecessors of the Breccia—belonged to the Pleistocene times of the Biologist, is seen in the fact that they were contemporary with Mammals peculiar to, and characteristic of, those times. This contemporaneity proves them to have belonged to the *Palæolithic* era of Britain and Western Europe generally, as defined by the Archæologist.

and this is fully confirmed by their unpolished tools of flint and chert. That they were prior to the deposition of even the oldest part of the Peat Bogs of Denmark, with their successive layers of Beech, Pedunculated Oak, Sessile Oak, and Scotch Fir, we learn from the facts that even the lowest zone of the bogs has yielded no bones of mammals but those of recent species, and no tools but those of *Neolithic* type; whilst even the Granular Stalagmite, the uppermost of the Hyænine beds in Kent's Hole, has afforded relics of Mammoth, *Rhinoceros tichorhinus*, Cave Bear, and Cave Hyæna.

That the men of the Cave Breccia, or Ursine period, to whom we now turn, were of still higher antiquity, is obvious from the geological position of their industrial remains. That the two races of Troglodytes were separated by a wide interval of time we learn from the Crystalline Stalagmite, sometimes 12 feet thick, laid down after the deposition of the Breccia had ceased, and before the introduction of the Cave-earth had begun, as well as from the entire change in the materials composing the two deposits. But, perhaps, the fact which most emphatically indicates the chronological value of this interval is the difference in the faunas. In the Cave-earth, as already stated, the remains of the Hyæna greatly exceed in number those of any other mammal; and it may be added that he is also disclosed by almost every relic of his contemporaries—their jaws have, through his agency, lost their condyles and lower borders; their bones are fractured after a fashion known by experiment to be his; and the splinters into which they are broken are deeply scored with his teeth-marks. His presence is also attested by the abundance of his droppings in every branch of the Cavern. In short, Kent's Hole was one of his *homes;* he dragged thither, piecemeal, such animals as he found dead near it; and the well-known habits of his representatives of our day have led us to expect all this from him. When, however, we turn to the Breccia, a very different spectacle awaits us. We meet with no trace whatever of his presence, not a single relic of his skeleton, not a bone on which he has operated, not a coprolite to mark as much as a visit. Can both, under the words "Iron" and "Beech," is intended to suggest that the "Iron Age" of Western Europe and the "Beech" zone of the Danish Bogs takes us back about equally far into antiquity; whilst the position of the line under the word "Bronze," indicates that the "Bronze Age" (still of Western Europe) takes us back from the ancient margin of the Beech era, through the whole of that of the Pedunculated Oak, and about halfway through the era of the Sessile Oak; and so on in all other cases.

KENT'S CAVERN.			PERIODS.				
Deposits.	*Bones.*	*Implements.*	*Archæological.*	*Danish Bog.*	*Biological.*	*Geographical.*	*Climatal.*
Black Mould.	Ovine.	Iron.	Iron.	Beech.	Recent.	Insular.	Post-Glacial.
		Bronze. and (?) Neolithic.	Bronze.	Pedunculated Oak.			
				Sessile Oak.			
			Neolithic.	Scotch Fir.			
Granular talagmite.	Hyænine.	Palæolithic Flakes.	Palæolithic.		Pleistocene.	Continental.	Glacial and (?) Inter-Glacial.
lack band.							
ave-earth.						Insular.	
Crystalline talagmite.	Ursine.	Palæolithic Nodules.				Continental.	
Breccia.							Pre-Glacial.

CORRESPONDENCE.

THE CYCADACEÆ IN THE "DAMUDA SERIES," AND THE NÜRSCHAN GAS-COAL OF BOHEMIA.

Sir,—I wish to send a few lines of explanation in reply to two letters which appeared in your Journal for April (pp. 189–191) last, which are intended to modify somewhat two statements in my papers previously published in the Geological Magazine (March Number, p. 105). With regard to the occurrence of *Cycadaceæ* in our Damuda series (and the Triassic facies of that series), the fact will be best established when I am enabled to publish the descriptions of all the fossils in a connected work with figures of all the forms. It will then be seen that so long ago as 1850 a true *Zamia* had been described from Burdwan as *Zamia Burdwanensis*, M'Clell. (which, as the original shows, is a *Pterophyllum*). The others have been subsequently found, although not examined at the time.

I wish to state that our *Nöggerathia*, from the Damuda series, does not agree with the genus as defined by Schimper, Weiss, and, more recently, by Prof. O. Heer; I have allowed the name to stand as a matter of convenience. Our *Nöggerathia* is more allied to *Zamia* than to any other genus.

My statement that the Nürschan Gas-coal of Bohemia was considered by Dr. Anton Fritsch to be a passage-bed, I am rather astonished to see denied by the "Questioner Himself" (see Geol. Mag. April, p. 191). I was of course not present in Glasgow at the meeting of the British Association, but in the report given in "Nature" for 21st Sept., 1876, p. 457, is the following passage:—"On Labyrinthodont Remains from the Upper Carboniferous (Gas-coal) of Bohemia. By Dr. Ant. Fritsch.—The Gas-coals of Bohemia are unusually rich in remains of Labyrinthodonts, fishes, and insects. They lie 'near the top of the Coal-measures' and 'are regarded by Dr. Anton Fritsch as passage-beds, the Fauna being of Permian and the plants of Carboniferous types.'" I think the reporter must have been correctly informed, or he would certainly not have written so distinctly.

But even if not so stated, it is no proof against their being considered such, and lying as they do, near the top of the Coal-measures, their close relation to the Permian series is sufficiently established on stratigraphical evidence, as clearly stated by Prof. Krejci's admirable paper, referred to in my article (March, 1877, p. 105).

Calcutta,
11*th May*, 1877.

Dr. Ottokar Feistmantel,
Palæontologist, Geological Survey of India.

[The publication of the above letter has, we regret to say, been inadvertently delayed.—Edit. Geol. Mag.]

THE

GEOLOGICAL MAGAZINE.

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No. X.—OCTOBER, 1877.

ORIGINAL ARTICLES.

I.—IS MAN TERTIARY? THE ANTIQUITY OF MAN IN THE ROMAN COUNTRY IN RELATION TO THE GEOLOGY OF THE VALLEY OF THE TIBER.

By Prof. RAF. D. P. MANTOVANI;
of the Royal Lyceum College, Rome.

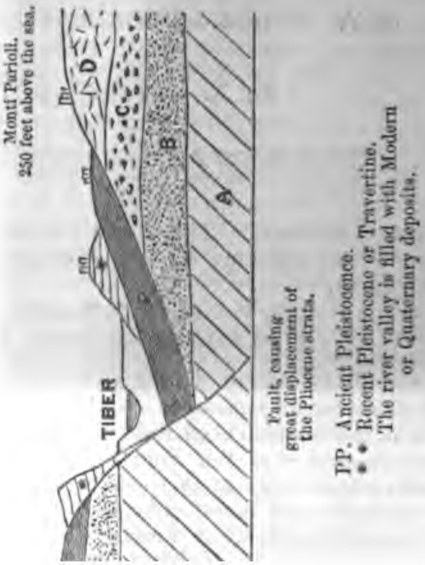
THE soil of the Roman country, so interesting to the archæologist for the splendid remains it has yielded of the Roman age, is no less rich in relics which shed light on the history of primitive man. Although researches of this kind began here only ten years ago, the results obtained up to this date have been highly satisfactory. These anthropological investigations have been executed with great care by many independent investigators, among whom .may be mentioned Ponzi, Ceselli, Bleicher, De Verneuil, and also the author of this communication, who have collected a great many specimens, and accumulated numerous observations relative to primitive Man.

To give a clear and accurate notion of the succession of prehistoric events in the Roman country, I think it will be useful to lay before my readers a brief general account of the geological formation of the Valley of the Tiber.

At the close of the elevation of the Tertiary strata, forming the great plain of the Roman country stretching from the foot of the Apennines to the shores of the Mediterranean, the ice and snow accumulated during the Glacial period began to melt, producing an immense quantity of water, which, running down to rejoin the sea, caused a considerable erosion of the plain above mentioned, and excavated the Valley of the Tiber, leaving the alluvial deposits upon the sides of the Pliocene hills. The direction of the channel was facilitated by a fault, the effect of a violent earthquake at the close of the Pliocene period. (See the annexed Diagram, p. 434).

Thus the geological structure of the hills has actually initiated this primitive valley. The hills are chiefly formed by strata of Pliocene age, flanked by alluvial deposits of the Pleistocene period. The Pliocene formation is represented by blue marl, overlain by thick beds of yellow sand and gravel, very rich in fossil shells, corresponding to the English crag. The Pliocene beds are everywhere covered

N OF THE VALLEY OF THE TIBER.



PP. Ancient Pleistocene.
* * Recent Pleistocene or Travertine.
The river valley is filled with Modern
or Quaternary deposits.

by superposed beds of volcanic tuff, the last and most extensive marine deposit of that period in the Roman country. This volcanic tuff was ejected from the volcano of Sabatini, actually represented by the group of mountains which now form the basin of Lake Bracciano. The Pleistocene strata are for the most part of mechanical origin, and in a less degree of a chemical nature. They result from the superposition of irregular beds of gravel, sand, and freshwater marl, containing pebbles of various sizes, derived from the detritus brought down from the Apennines. Limestone and *polierome* silex are most abundant, but a great quantity of broken crystals of volcanic minerals, as augite, leucite, olivine, etc., are mixed with and compose the gravel and sand.

This volcanic debris has been derived from the decomposition and erosion of the tuffs, or from the *Latial* Volcanos, whose eruptions were contemporaneous with the formation of the valley of the Tiber.

The chemical deposits are only seen in the broader expanses of the valley, and result in the deposition of vast beds of *travertin*, a freshwater limestone of very uniform texture, and largely used in ancient and modern buildings.

The earliest traces of primitive man consist of angular fragments of silex evidently artificially worked. This silex is usually met with in the form of flint-flakes or knives, spear or arrow-heads, and celts or hatchets. These weapons are always chipped out roughly, their surfaces are never smoothed or polished, consequently they are referable to the Palæolithic or Archæolithic era of prehistoric man.

In the same river-valley gravel, commingled with the worked flints, are frequently found the bones of fossil Mammalia; of these relics of the extinct fauna of the Roman country, the most abundant are:

Bos primigenius, Boj.
Elephas primigenius, Blum.
——— *meridionalis*, Nesti.
——— *antiquus*, Falc.
Cervus elaphus, Linn.
Hippopotamus major, Nesti.
Rhinoceros tichorhinus, Cuv.
Sus scrofa, Linn.

Others less common are:

Hyæna spelæa, Goldf.
Castor Europæus, Owen.
Ursus spelæus, Blum.
Cervus (*dama*) *Romana*, Ponzi.
Bos latifrons, Cus.

The latest researches of this kind have disclosed a fact of the highest importance, namely, that flint implements have been discovered in the gravel forming the upper portion of the Pliocene deposits (see Diagram, Bed C.). I have collected some of these flint implements myself on the Pliocene hills of Janiculus and the Vatican; but I must sincerely confess that the evidence of their having been artificially formed appears to me to be open to doubt. On the contrary, however, the flint implements of the alluvial deposits leave no doubt as to their having been artificially formed by the hand of man. For the present therefore we will only consider these undoubted traces of man contemporaneous with the great Mammalia in the Quaternary deposits.

The first and most evident conclusion that may be drawn is, that the alluvial deposits having, as already stated, been produced by the action of water derived from the melting of the snows of the glacial epoch, it follows that the animals, whose remains occur therein, and the makers of the flint implements associated with them, were living before the Glacial period which destroyed so many of the great Mammalia.

Man must therefore have appeared at the end of the Pliocene period, and during this early time he was in the Palæolithic era, as evidenced by the fabrication of his weapons of silex. No metals nor pottery of any kind have been found in these formations.

Let us now examine the evidence relative to man during the Neolithic age. The Roman country is very rich indeed in remains referable to this more recent epoch. Everywhere in the surface soil are found extraordinary quantities of flint knives and spear-heads, finely formed and polished, and sometimes magnificent hatchets of smoothed stone. These objects are not only found scattered over the surface of the soil, but they are frequently met with accumulated in limestone caverns, imbedded in stalagmite, and associated with them are the fragments resulting from the manufacture of the weapons themselves, in fact a true manufactory of Neolithic implements; a thing unknown in the Palæolithic period, the weapons of which are so inferior in finish and workmanship.

Whilst antiquaries divide the prehistoric period into two distinct epochs, namely, the *Palæolithic* (or Archæolithic) and the *Neolithic*, the difference in workmanship between the objects which have been found is so great, that for a long time I believed it might be possible to define an intermediate or transition period from the Palæolithic to the Neolithic. And, indeed, I believe we have found in this district objects just described, some beautiful vessels of perfect work, resembling those of the ancient Etruscans. There have also been occasionally found hatchets perfectly polished, made of a kind of stone (a Jadeite) that is not found in Italy. From what region were these objects derived? My opinion is that a foreign and more civilized people was in communication with the native inhabitants of Italy during this period, and that a kind of commerce was probably established, and that in process of time this people (certainly a more advanced and civilized race) became the invaders, and that the primitive population of Italy, being less civilized, disappeared entirely.

Upon such an hypothesis the presence of metals mixed with these flint implements and this rude pottery may easily be explained. For it cannot be supposed that a race of men who had attained to the art of separating metals from their ores by smelting, should yet continue to manufacture flint-weapons, and to use them in preference to those of bronze or iron.

I prefer rather to adopt the conclusion that the introduction of metals is good evidence of the presence of a more civilized foreign people, who at first were in occasional communication with the preexisting population for purposes of trade, and in later times occupied the country. It is necessary to observe that the metallic objects met with consist for the most part of spears and hatchets carefully cast in bronze, which, although an easily fusible material, proves that the people who worked in it were well instructed in the use of the ores of copper and tin. We do not find any trace of iron, the use of which is certainly referable to a posterior age, owing no doubt to the greater difficulty attending the treatment of this metal.

I believe that prior to the introduction of bronze, some metals more easily fusible were employed, and I remember to have once examined a leaden spear-head of rough workmanship, but which had evidently been fused and moulded. This object was found in a bed of Quaternary gravel. But this single fact is scarcely sufficient by itself to establish that lead was the first metal employed by man, although the instance above cited seems deserving to be placed on record.

From the facts stated it seems to me that the existence of a transition period between the Palæolithic or Archæolithic and the Neolithic ages (which I would propose to name the *Miolithic* period) is admissible, and it would be of great importance to learn whether the researches carried on in other countries give the same results as those which have been obtained here.

Certainly in Central Italy this transition period is distinctly indicated, and marks a very clear epoch in the primitive history of human civilization.

Admitting then this new period which I have proposed, and taking the Archæolithic or Palæolithic period as a point of departure, to this would succeed the *Miolithic*, and I conceive that during this middle period the primitive inhabitants of Central Italy were divided into two different populations, which were probably represented by two distinct races; the one, primitive or native, which continued to use flint weapons, perfecting their manufacture during the successive Neolithic period; the other of more recent introduction (but certainly derived from a more ancient and more highly advanced race as regards its progress in civilization), which, invading the country, gradually superseded the aboriginal flint-implement-making race.

According to this view, the Latin population which actually inhabits the Italian peninsula does not represent the primitive race, but they are the descendants of an exotic people who brought to Italy a civilization much in advance of the aboriginal race.

If it be asked from whence came those early foreign settlers, I think it will not be difficult to prove that they came from Asia, where we also find remains of monuments of the highest historical antiquity, affording records of the most ancient period in human civilization.

The introduction into Italy of this exotic population is referable to the dawn of the modern epoch, whereas the primitive inhabitants of Italy were existing from the end of the Pliocene period, when all the plains now stretching on both sides of the Apennines were covered by the sea, and when the latest Tertiary deposits were being spread over their submerged surfaces. In this remote time Central Italy was represented by an archipelago of mountainous islands, the Apennines being washed to their feet by the waves of the Pliocene sea. Even then primæval man inhabited the mountains, and their calciferous caverns were his sole retreats, nor could he descend into the plains until after their upheaval, when he doubtless witnessed the gradual formation of the great Quaternary alluvial deposits and the eruptions of the Latial Volcanos.

RECORDS OF PREHISTORIC MAN IN THE ROMAN COUNTRY.

Geological Periods.	Nature of the Deposit.	Periods in the History of Man.	Evidences of Man's presence.
IV. Modern or Quaternary.	Recent alluvial deposits and surface-soil of the country.	Neolithic.	Flint perfectly cut and worked; hatchets of Jadeite; pottery with the first pictures.
III. Newer Pleistocene.	Travertine volcanic products of the Latial Volcanos.	Miolithic.	Silex well polished, but not perfectly cut; rough pottery mixed with a finer quality; metals (bronze).
II. Ancient Pleistocene.	Gravel, sand, and marl, with the bones of great Mammalia.	Palæolithic or Archæolithic.	Flint implements of a more perfect workmanship; Metals ? (Lead).
I. Upper Pliocene.	Gravel and yellow sand with marine fossils (= Crag Mollusca.)	First appearance.	Flint implements roughly worked.

II.—The Antiquity of Man.

By J. R. Dakyns, M.A., of H.M. Geological Survey.

Of all geological questions, perhaps that of the Antiquity of Man is the most popular. Nor is it one on which geologists have been rash or hasty in advancing new ideas; quite the reverse: they have lagged behind the evidence. In the "Principles of Geology," one of the most instructive chapters is that in which the author treats of the progress of Geology. Therein Sir Charles Lyell has shown how the science had been retarded for three hundred years by men's reluctance to admit such a simple and obvious matter as the marine origin of stratified rocks, owing to a fixed idea that the world had come into being a short time since in much the same state as it appears to-day. Yet the illustrious author of the "Principles of Geology" let pass for thirty years the evidence that Man was contemporaneous with the extinct Pleistocene mammalia. In 1833 the evidence on this point was nearly as complete as it is now; but it was practically neglected because it did not square with preconceived ideas. In fact, it was not accepted till Lyell himself, reviewing the facts in his usual masterly manner, summed up judicially in favour of the new views in his first edition of the "Antiquity of Man." Now, to compare great things with small, a like reluctance to admit new evidence on the subject is widespread. *Then* the prejudice was that man was modern, that he never saw old-world mammals any more than Silurian forms of life; *now*, admitting perforce his co-existence with the Pleistocene mammals, the prejudice is that he should be considered post-Glacial. Yet, geologically, the question is practically settled by the evidence afforded by the Victoria Cave. There the usual Pleistocene fauna is found overlain by a true glacial deposit. Whether or not the bones of man have really been found there, is a question for osteologists to determine; but though of great, this is not of the first importance. The fauna is that often associated with man; therefore, without prejudice, we conclude that, what is true of them as to age, is also true of him: whether or not a human bone has been found in that particular collection is comparatively unimportant. As, however, owing to the reluctance shown in certain quarters to admit the evidence, the simplicity of the geological question is not generally known, a short summary of the facts and arguments may be of interest. At the Victoria Cave the remains of Hyæna, Fox, Brown Bear, Grizzly Bear, *Elephas antiquus*, *Rhinoceros leptorhinus*, Hippopotamus, *Bos primigenius*, Bison, and Red Deer, and a questionable fibula, have been found in the lower cave-earth. The ends of this deposit were covered by a mass of erratic boulders and of till. This was a true glacial deposit, as I have myself seen. This glacial deposit immediately overlies the Cave-earth containing the Pleistocene mammalia, without the intervention of any talus; but it was itself covered by an enormous mass of talus, twenty feet and upwards in thickness, composed of limestone fragments, fallen from the cliff above, without the intermixture of any boulders whatever.

This sequence of deposits, consisting of:—

Modern screes, resting upon
Glacial Boulder-beds, overlying
Cave-earth, with the Pleistocene fauna,

sufficiently establishes the fact that the animals, whose remains have been there found, lived in the country before the end of the Glacial period. This is perfectly simple: but it is contrary to the common opinion formed entirely upon the evidence gleaned in a very different part of the country, to wit, the Ouse and Thames basins, where the said fauna is post-Glacial. So prejudice sets to work and puts its votaries through remarkable contortions. First, it is suggested that the boulders are not a true glacial deposit in place, but have tumbled into their present position off the cliffs above. This is simply impossible, and therefore the suggestion is absurd, for the following reasons:—Had the boulders fallen off the cliff in the course of its weathering, they would be mixed up with ordinary talus and screes. But they are not so; they form a distinct deposit by themselves. Moreover, one cannot suppose, if one would, that a nest of boulders and a patch of Boulder-clay had been providentially, though most improbably, placed on the top of the scar above the mammalian remains, so as to fall in a lump and leave not a stone behind to mix with the subsequent screes, for this reason: restore to the cliff the amount of rock that has subsequently fallen as screes upon the boulder-bed, and make due allowance for the enormous amount that has been carried away in solution without leaving a trace behind; restore all

the cliff, and it will project so far over the site of the
r-beds as quite to preclude the idea of their having fallen
he cliff above. But drowning sceptics catch at straws. So
re a further exhibition of intellectual contortion. It is now
d by the sceptical geologist that the boulder-bed has come
h a providential pot-hole or pipe, "of which," it is said,
are plenty in the limestone above." Memory, when sceptical,
inly creative. The limestone plateau above is singularly free
ot-holes: there is not one of any great size within many a
e nearest being Gingling Hole, more than three miles distant;
nuch doubt whether there are any worthy the name nearer.
en had they been tolerably abundant, has the ingenious author
theory ever seriously asked himself what are the chances
ot-hole occurring just in so very convenient a situation, and
he chance of the cliff having just weathered back far enough
roy this providential pot and no further? When he has got
a of the smallness of these chances separately, let him then
our to estimate the probability of their both having occurred
r. I rather fancy the figures will somewhat astonish even
ptic. So much for the geological question, the chief points
h have been insisted on over and over again by Mr. Tiddeman.
egards the palæontological question, Mr. Tiddeman's argument
ply this: here we have a fauna which is elsewhere often
ted with the remains of man; whatever be the age of this
is presumably also that of man; in the Victoria Cave we have
e that this fauna existed before the close of the Glacial
; therefore, presumably, man existed in this country also
the close of that period. The fact that the said fauna with
remains is post-Glacial in the South of England is to be
ed by the consideration that the last glaciation of the country
t extend over the South of England. This consideration too
s the remarkable fact, that no Pleistocene fauna has been
in river-gravels in the North of England. Why should such
a, when found in river-gravels, be confined to the south?
because the last glaciation has swept away all the river
s of that age from the north; but as it did not extend to the
the old river-gravels of that district have escaped destruction,
main to-day to be seen with their included fauna.

III.—REVERSED FAULTS IN BEDDED SLATES.

By E. J. HEBERT, M.A., F.G.S.,
of H.M. Geological Survey.

be an established rule, in coal-mining districts, that the hade
a fault is to the *downthrow*, it is an equally undeniable fact,
e surfaces of bedded slates, as a rule, exhibit only faults
hade to the *upthrow*. In suggesting a possible explanation of
enomenon, I shall allude to the latter as *reversed*, and the
as *direct* faults. Let Fig. 1 represent a piece of wood six
square and one inch thick, lying upon a table, and let it be

sawn through diagonally as indicated; apply equal and
pressures P, P, Q, Q, at right angles to each of the sides
middle points, as indicated by the arrows in Fig. 1. The

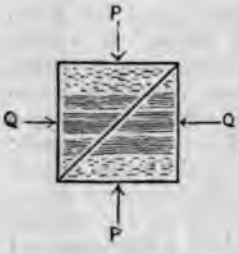


Fig. 1.

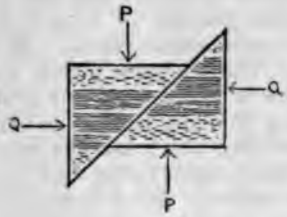


Fig. 2.

Fi

equal to Q, there is no tendency to a displacement; whe
be greater than Q, the square has a tendency to assume th
Fig. 2, and if P be less than Q, of Fig. 3. Now sup
square, instead of being of wood, and lying on a table, for
of the earth's crust, and stands vertically, the grain of
being replaced by the strata of which the crust is made up
the vertical pressures upon the sides of this square of roc
the horizontal, the strata of which it is made up will
assume the form indicated by Fig. 2, *i.e.* a *direct* fault will
take place; whereas if the horizontal pressures exceed the
the strata will tend to take the form of Fig. 3, *i.e.* a *rever*
will probably ensue.

These tendencies, however, will not of necessity result
since any displacement may be prevented by the more or
connexion of the square of rock, under consideration,
adjoining strata, of which it forms a part. Friction also, a
a multitude of other modifying causes, will influence th
Now since it is probable, where strata are tolerably free
tortion, as in the English Coal-measures, that vertical
have exceeded horizontal pressures, (arguing as above) w
here expect to meet with *direct* faults; but since it is
highly contorted and cleaved strata, as in the English ar
slates, that horizontal pressures have at one time far exc
vertical pressures, we should here similarly expect to me
with reversed faults; and in each case our surmises wou
correct.

It should, however, be remarked, that the above are consi
of the most simple case, and in practice we should meet w
variations which would modify the result. First and
amongst these should be mentioned that the hade of the f
seldom happen to be 45° (as in the figures), a lower hade t
neutralize the motive power of the vertical pressures, and
that of the horizontal pressures, while if the fissure be ver
horizontal pressures will have no motive power at all. Sti

Geol. Ma

F. Schliep del.

VER SÄNKÄREW

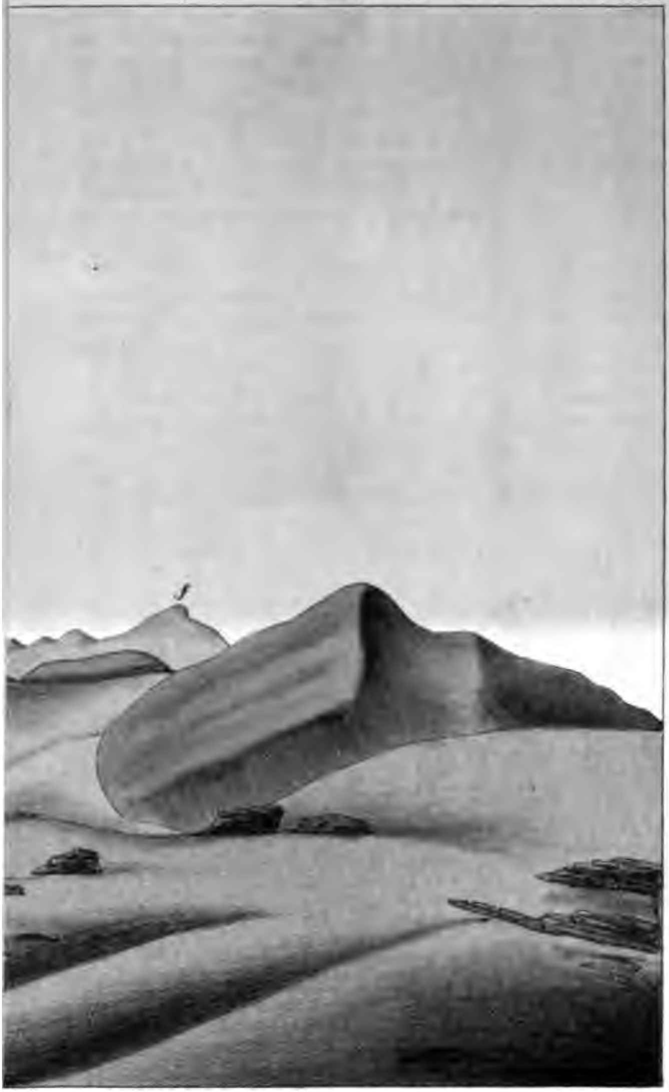
▨ 8.

Coalfield ....

lfield .....

-ian Coalfield

NG, WEST



ANG.

Stanford imp.

Limestone with Fusulinae ▭ 2.

Syenite ▭ 1.

} *Oembilien Coalfield.*

COAST OF SUMATRA.

complications will ensue when the horizontal pressures are of such a direction as to produce a certain amount of lateral shift in the strata on either side of the fault, as would be the case in our illustration, if the square of wood were not sawn *at right angles* to its surface, but with the saw on the slant, in which case, the pressures being applied, the two pieces of wood would no longer tend to move in the plane of the square; and it is here necessary to remark that reversed faults resulting from the horizontal pressures accompanying cleavage, will not be exhibited on the cleavage faces of bedded slates, except where the pressures have a direction similar to that last referred to, *i.e.* such as would produce a certain amount of lateral shift. But as this oblique position of the fissures with respect to the pressures will be of most frequent occurrence, we should expect the greater number of faults resulting from cleavage pressures to be exhibited upon the *faces* of the slates.

The above modifications do not, however, destroy the general inference, that direct faults are indicative of excessive vertical pressure, and reversed faults of excessive horizontal, or lateral, pressure.

IV.—THE GEOLOGY OF SUMATRA.

By M. R. D. M. VERBEEK,
Director of the Geological Survey of the West-Coast, Sumatra.

(PLATE XIV.)

(Communicated by Professor T. Rupert Jones, F.R.S., of the Royal Military and Staff Colleges, Sandhurst.)

THE Geological Panorama, Plate XIV., prepared by M. R. D. M. Verbeek, is in further illustration of his Memoir[1] "On the Geology of Central Sumatra," in the GEOL. MAG. 1875, New Series, Dec. II. Vol. II. (No. 136), pp. 477–486; and it gives a view, from north to south, of a most interesting part of the Highlands of Padang, namely the Oembilien Çoal-field.

To the left the syenite is covered by sandstones and breccias of the group "5*a*." The quartz-porphyry of Mount Toenkar conceals the greater part of the Parambahan Coal-field. Then follows the Sigaloet Coal-field, with its beds dipping south; on the other side of the River Oembilien the sandstones of the Soengei-Doerian Coal-field are seen dipping to the north. These three coal-fields form together the Oembilien Coal-field. More to the right (south) follows the old limestone with *Fusulinæ*,[2] and the greenstone (pyroxene-porphyry). The hills between the Coal-field and the point from which the panorama was taken are composed of breccias and marl-slates of the oldest part of the Eocene formation (*5a*); the latter contain, on the River Sänkärewang, remains of Fishes and Plants.

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[1] See also GEOL. MAG. Dec. II. Vol. III. p. 382, for some verbal corrections in this memoir; also Vol. II. pp. 532–39, Plates XIII. and XIV., for Mr. Brady's description of some Fossil Foraminifera from Sumatra; and GEOL. MAG. Dec. II. Vol. III. pp. 433–40, Plates XV.-XIX., for Dr. A. Günther's description of some Fossil Sumatran Fishes. This coloured Panorama, like the foregoing Plates, has been executed under the auspices and at the cost of the DUTCH-NETHERLAND GOVERNMENT.

[2] In the Neues Jahrb. 1876, p. 415, M. Verbeek mentions the discovery of *Productus semireticulatus*, *Phillipsia*, and *Goniatites* in the Fusulina-limestone of Sumatra.

The following summary, by Prof. H. B. Geinitz and Dr. W. v. d. Marck (*Report Imp. Geol. Instit. Vienna*, August 31, 1876), of the information they have obtained on the geology and fossils of Sumatra, may be introduced here with advantage.

Mr. R. D. M. Verbeek has noticed the following succession of rocks (in ascending order) near Fort Van-der-Capellen, West-Coast, Sumatra.

1. *Grey Limestones* abounding with a large spherical form of *Fusulina* (belonging to the group of *Fus. robusta*, Meek), and the ossicles of Crinoid stems. This *Fusulina* approaches very near the Carinthian form *Fus. globosa*. Prof. Geinitz's *Fus. Verbeeki* is identical with Ehrenberg's *Borelis princeps* from the hornstone of the Carboniferous Limestone near Archangel. These limestones may be ranked in the Upper Carboniferous, or eventually, perhaps, in the Inferior Dyadic (Lower Permian) Series.

2. *Marl-shale Formation* [*Marl-slates*], dark-grey, thinly laminated shales, with remains of *Fishes*, analogous to those of Glaris. These Shales, immediately resting on greenstones, are considered by Prof. Geinitz and Dr. von der Marck to be a connecting link between Cretaceous and Eocene deposits; and by Professors Herz and R. Jones to be Eocene. [Dr. Günther, however, has indicated their very close alliance with recent forms.]

3. *Sandstones with Coal-seams*, without organic remains, nearly 1000 feet thick, resting unconformably on the Marl-shales. The only fossils in them are undeterminable stalks and leaves of plants, small *Melaniæ*, and traces of Fish.

4. *Marly Sandstones*, very far spread; a marine deposit with remains of *Ostrea*, *Pecten*, and *Serpula*.

5. *Coral-limestones* (rather extensively overlying group 4); including internal casts of Gasteropods and Conchifers, together with *Echinidæ* comparable with the Eocene forms *Prenaster Alpinus*, Desor, and *Periaster sub-globosus*, Desor.

The fossil Fishes from the laminated, black-brown, bituminous shales, with Coprolites, have been described by Dr. W. v. d. Marck as four new species, namely, *Protosyngnathus Sumatrensis* [*Auliscops Sumatranus*, Günther], *Sardinioides amblystoma* [*Thynnichthys amblyostoma*, Günther], *Brachyspondylus saropteryx*, and *B. Indicus* [*Pseudotropius Verbeekii*, Günther]; and in his opinion this fauna, especially *Sardinites*, allows him to parallelize these shales both with the uppermost Cretaceous beds of Westphalia and Syria and with the Eocene fish-beds of Monte Bolca, and thus to regard them as an intermediate link between Cretaceous and Eocene, and analogous to the "Liburnian" horizon of Istria and Dalmatia.—*Report Geol. Instit. Vienna*, August 31, 1876.

Dr. Günther points out (*op. cit. suprà*, p. 434) that of the nine genera of Fishes represented in the Sumatran Collection which he examined, all but one have *living* species, mostly in India and Sumatra.

V.—THE MIGRATION OF SPECIES AS RELATED TO THE CORRELATION OF GEOLOGICAL FORMATIONS.

By CHARLES CALLAWAY, M.A., B.Sc., F.G.S.

THE topic of this paper is suggested by a somewhat extended practical study of the fossils of North America. A comparison of these forms with our European faunas will, I think, throw some light upon migration, and upon the correlation of strata.

When comparing western with eastern formations, we are thrown back chiefly upon the testimony of fossils. Mineral resemblance, such as is observed between the Wenlock Limestone and Shale in the east, and the Niagara Limestone and Shale in the west, is of little value at great distances. The Wenlock Limestone, for instance, passes into an arenaceous deposit towards Wales, and the Niagara Limestone thins out towards the east in the State of New York; so that the continuity of the two formations is an extreme improbability. Stratigraphical position, the third test of contemporaneity, is also of little service, and is itself dependent upon fossil evidence. We cannot, for example, justly argue that the Niagara group of New York represents our Wenlock on the ground of its stratigraphical position, unless we admit that the formations overlying and underlying it correspond respectively to our Ludlow and May Hill Sandstone. But we can prove that correspondence only by stratigraphical position, which would land us in absurdity; or by fossils. The uncertainty of mere stratigraphical evidence is well illustrated by the Devonian and Old Red Sandstone of South-western Britain; and, if this method of proof is so dubious in the case of formations separated by the Bristol Channel, it is obviously much more untrustworthy when applied to groups on opposite sides of the Atlantic Ocean.

It has been maintained that *identity of species, so far from proving contemporaneity, is an evidence of non-contemporaneity.* If, for example, a species migrates from Britain to America, it is clear that the beds containing it in America are newer than the strata which contain it in Britain. This is undoubtedly true if we use the word "contemporaneous" in a strictly historical sense. It is evident that the whole of the formation in America characterized by a certain fauna cannot be contemporaneous with the whole of the series in Britain containing the same fauna; the former will be later than the latter by the time occupied in the migration of the fauna a distance of 3000 or 4000 miles. This is on the supposition that the migration was from east to west. It is possible, however, that the fauna may have originated in some intermediate centre, and spread both east and west; in which case eastern and western formations, characterized by the same (or a similar) fauna, may be strictly contemporaneous. Even on the extreme supposition of an east and west migration, I shall attempt to show that the time occupied in the migration is unimportant in comparison with the duration of geological epochs.

It must be remembered that, for purposes of correlation, the group of the Mollusca are the most important. This is emphatically the case with the older Palæozoic fossiliferous groups, in which molluscs are the predominant forms of life. Brachiopoda, especially, abound in all epochs, from the Cambrian to the Carboniferous, and are most valuable for our purpose. Molluscous faunas are of very wide distribution even in the present day. Dr. Krauss informs us that *Ranella granifera* ranges from the Red Sea to New Zealand, *Purpura lapillus* from Greenland to the Cape, *Venus verrucosa* from Britain to the Cape. Dr. S. P. Woodward (Manual Moll. p. 60) states that, "out of 270 sea-shells found on the coast of Massachusetts north of Cape Cod, more than half are common to Northern Europe." In wider seas, species have a still greater extension. In the great Indo-Pacific province, including "three-fifths of the circumference of the globe and 45° of latitude," the facies of the fauna is uniform. "Mr. Cuming obtained more than 100 species of shells from the eastern coast of Africa, identical with those collected by himself at the Philippines, and in the eastern coral islands of the Pacific." In Palæozoic times, the conditions for the extension of species were undoubtedly more favourable than in most recent provinces; and, in all probability, closely resembled the conditions now prevailing in the Indo-Pacific province. That resemblance is seen chiefly in two points: in freedom from extremes of temperature, and in continuity of marine conditions. In proof of the latter point, it will be necessary to show that the sea was open from the eastern to the western hemisphere in Palæozoic times. It is highly probable that the southern part of what is now the northern Atlantic was occupied by continental land; but that the sea was open towards the north will, I of migrating *en masse.* It certainly was not so in Palæozoic times. A few examples will suffice to illustrate this. *Pentamerus galeatus,* a species which, in Britain, commenced its existence in the Wenlock period, is not found in any American formation below the Lower Helderberg group, the representative of our Ludlow. *Pentamerus oblongus,* which in the eastern hemisphere and in eastern North America is not found higher than the Clinton group (our May Hill Sandstone), ascends into the Niagara (Wenlock) formation in more westerly localities. A more striking example may be cited. Our Ludlow rocks are characterized by an abundant Lamellibranchiate fauna, notably by the genera *Pterinea, Goniophora,* and *Cypricardinia.* In North America, this fauna is represented, not in Silurian, but in Middle Devonian (Hamilton) rocks, by forms which, in some cases, are specifically identical, and, taken as a whole, are strikingly similar. We are bound to regard the Hamilton as true Devonian, since it lies above strata with a distinctively Devonian facies, and far above formations which clearly represent our Upper Silurian groups. In all these cases, the migration must have been from east to west. On the other hand, the Merostomata flourished in the Water-lime formation (Upper Wenlock) in the west; but in the east they do not appear till the Ludlow period; the migration being obviously from west to east.

Equability of climate over large areas in Palæozoic times must have been highly favourable to migration. The President of the Geological Society, Prof. P. Martin Duncan, in his anniversary address in February, suggests that our earth is losing its atmosphere, as the moon has already lost hers; and, consequently, our atmosphere must have been denser in earlier periods. This would probably account for the greater equability of climate which we infer on palæontological evidence to have existed in Palæozoic epochs. If, then, migrations were wider and more rapid in ancient periods, fossils must be even better tests of contemporaneity than in younger formations.

VI.—NOTES ON THE DEVONIAN ROCKS NEAR NEWTON ABBOT AND TORQUAY; WITH REMARKS ON THE SUBJECT OF THEIR CLASSIFICATION.[1]

By HORACE B. WOODWARD, F.G.S.,
of the Geological Survey of England and Wales.

[Read before the British Association at Plymouth, August 16th, 1877.]

WHEN we consider the growth of geological knowledge in our own country, we soon learn how very detailed must be the character of all new work compared with that performed by the great pioneers in the science. Much that has now to be done may be called the microscopic work, labour that is often uninteresting and dry, except to the individual himself, but which nevertheless is most useful and necessary.

The more or less rapid traverses of the earlier geologists enabled them to produce sketch-maps, and in most cases to grasp the main geological features of the country when they could not attempt to follow out all the local points of structure; and when we remember that they had to start as it were in a *terra incognita*, we may well speak with admiration of the grand work that was achieved in field-geology in the early part of this century.

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[1] This paper is communicated by permission of the Director-General of the Geological Survey of the United Kingdom.

While the greater portion of England and Wales has now been worked out in considerable detail, and its rocky structure represented upon the Geological Survey maps, our knowledge of the Palæozoic country of West Somerset, Devon, and Cornwall, is almost entirely confined to sketch-maps, showing the general grouping of the strata; the determination and correlation of minor subdivisions in the rocks, and the tracing out of their exact boundary-lines, having been as yet attempted only in a few localities.

Thus the geological picture sketched partly by Sedgwick and Murchison and Godwin-Austen, remains for the most part very much as it was when left by the master-hand of De la Beche. And here it is only right to observe that the maps of this district, which were those first published by the Geological Survey, were the work of De la Beche as an amateur, assisted only by the voluntary contributions of other private workers. Consequently the same attention to minute accuracy with which he subsequently directed the labours of his staff, could not possibly have been given to this early work, which covered an extent of ground that no one man could have thoroughly investigated in a lifetime.

Another grand version has, however, been given to the geological outline of this district, and by a man whose experience put him at least on a par with any of his predecessors. A considerable modifi noting a few facts in the local geology, some remarks be made on the work that has been done, so that if possible more labourers may be tempted to come into the field.

During a year's residence at Newton Abbot (1874–75), while engaged in the revision of the boundaries of the Secondary and newer deposits, I was enabled to gather a few facts which may be of interest concerning the succession of the Palæozoic rocks in that neighbourhood; but I should mention that my work was restricted to the older rocks immediately bordering the Secondary strata, as a revision of the Palæozoic rocks is postponed, so far as the Geological Survey is concerned, until the Six-inch Ordnance Maps are issued.

The published maps of the Geological Survey show but two general divisions in the Devonian rocks, the slaty group having one colour, and the limestones another. The relations of these are not exhibited, and one might conclude that the limestones occurred at different horizons as great lenticular or isolated masses. A careful examination of the ground, however, soon dispels this notion; and when the boundaries are traced out, it will be found that the frequently abrupt terminations of the limestone are due to well-marked faults. Wherever positive evidence was to be obtained, a definite sequence in the Devonian rocks was manifest—the limestones forming an upper group, the slates a middle one, and red sandstones a lower group. It must be admitted that this positive evidence is not often obtained in sections actually showing a junction or superposition, but it is very clearly established when the beds are traced out over the ground. The relation of the rocks to the form of the country is very clear, and the actual boundary-line between the limestones and the slates beneath may usually be defined within a few feet. When, as is often the case in some limestone quarries, the dip of the beds cannot be distinguished amidst the cleavage and jointing, the general inclination can be determined when the boundary with the slates has been drawn, according as the line runs a long way or but a short distance into the ravines and valleys that intersect the escarpments. In this way the little masses of limestone mar Woolborough and the slates of Abbots Kerswell, as noted by Jukes and Dr. Holl, can be readily correlated with the Devonian limestones and slates, instead of being classed with the Culm-measures, as represented on the Geological Survey Map. These beds are abruptly faulted against the Culm-measures on the west.

The slates may be clearly traced beneath the limestone south-east of Daccombe, at Barton, Anstey's Cove, Wickaborough, and other places. The boundary with the red sandstones beneath is not so well marked, for the lithological characters are not so sharply defined, nor have we the benefit of the springs which are thrown off at the junction of the slates with the limestone.

The relations of the red sandstones to the beds above are, however, well shown at Cockington. A quarry about a quarter of a mile north-east of Livermead shows beds of red sandstone dipping a little to the east of north, while further west they are shown dipping a little to the west of north. We may trace the slates above them at Cockington village, and if we proceed up the valley by Stanton, we come upon the limestone dipping at from 20° to 24° a little to the west of north. At the bottom of the valley immediately to the east of Barton, thin flaggy red sandstones may likewise be traced beneath the slates.

In 1875 a well-section was made by the Diamond Rock Boring Company's process for the Torquay Brewing and Trading Company in Fleet Street, Torquay. The following details were kindly communicated to me by Mr. T. Perry, B.A., and although the boring was not carried sufficiently deep to supply all the requirements of the geologist, the facts are nevertheless of sufficient interest to be noted. They are as follows: —

Petitor Marble	about	92	feet		
Plain Limestone	„	247	„	8	inches.
(Hiatus of two or three feet filled with soft tenacious red clay.)					
Blue Slate	„	82	„	9	„
Chocolate Slate	„	65	„	7	„
Blue Slate	„	98	„	0	„
Indurated Red Marl	„	42	„	7	„
Depth of boring		628	ft.	7	in.

The inclination (or "natural cleavage" as it was termed) of the limestones was about 70°, whereas the inclination of the slates was no more than 45°; and this difference I am inclined to think is due to a fault between the two which runs north-west and south-east along the margin of the limestone that extends from Torquay Harbour to Daddy Hole.

Owing to this inclination, the thickness of the beds passed through may be estimated as follows:—

Limestone	130	feet
Slates	185	„
Red Marl	25	„

Concerning the so-called "Indurated Red Marl," I saw a specimen which seemed to belong to one of the junction beds between the slates and red sandstones, but it would be hazardous to express any more definite opinion about it.

The succession of limestones, slates, and red sandstones here pointed out is not new: the results of my own field-work rather coincide with the views expressed fifty years ago by De la Beche. Nevertheless, a different interpretation was put upon the structure of South Devon by Dr. Holl; and De la Beche himself was led in after years to modify his opinions concerning the classification of the beds, so as to conform with the views of Sedgwick and Murchison. It was in 1827 that he gave an account of the geology of Tor and Babbacombe Bays. The limestones he then termed Carboniferous Limestone, stating that the beds "contain fossils that have been discovered in the Carboniferous Limestone of other places, and, though a matter of minor importance, mineralogically resemble it; they are, moreover, separated from the Old Red Sandstone by a shale, which may be considered the equivalent of the Lower Limestone Shale."[1]

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[1] Trans. Geol. Soc. 2nd ser. vol. iii. p. 163.

He described the Old Red Sandstone of Cockington as "chocolate-coloured, micaceous, siliceous, and very compact sandstone."

The fact that the Devonian slates and limestones in South Devon, as well as in North Devon, are underlaid by beds resembling the Old Red Sandstone, is most important. Almost every writer speaks of their mineralogical resemblance. So far as I know, the beds at Cockington have yielded no organic remains, but I obtained some obscure plant-like markings.

We can draw no such close comparisons between the Devonian Slates of South Devon and the Lower Limestone Shales, although there are local resemblances. The former beds are, however, much affected by cleavage. In West Somerset some of the Devonian slaty beds are much like the Lower Limestone Shales of the Mendip Hills.

When we come to the Devonian Limestone, we find a great and striking mineralogical resemblance to the Mountain Limestone. Some beds are of a dense blue colour, with few veins of calcite; others again are very freely veined with a fine network of spar, or contain broad bands of crystalline matter. Beds of nearly white limestone occur near Ideford, others again are Oolitic in structure. It may be remarked, also, that many of the beds of Devonian Limestone, when fractured, emit the same sulphurous smell as does the Mountain Limestone; while the slaty beds beneath sometimes exhibit similar alternate bands and nodular beds of limestone. So that almost every lithological feature that one may observe in the Mountain Limestone of the West of England is repeated in the Devonian Limestone of Devonshire. This reminds me that a few years ago, when writing in conjunction with Mr. Bristow about the much-abused limestone of Cannington Park, near Bridgewater, we spoke of its striking resemblance in all particulars to the Mountain Limestone. I can only add now that lithologically the Cannington Park Limestone is as much like the Devonian as the Mountain Limestone.[1]

Sedgwick and Murchison noticed the occurrence of "thin laminæ of bright coal" in the limestone near Plymouth.[2] Mr. Godwin-Austen too observed that "the limestone of the Ashburton band is exceedingly carbonaceous, containing even seams of anthracite," and he detected the same feature at Totnes. He considered the formation of the carbonaceous matter to be due to marine rather than to terrestrial vegetation.[3]

The weathering of the Devonian Limestone is naturally similar to that of the Mountain Limestone. Some of the honeycombed surfaces that may be seen on joints and exposed edges of the rock in a quarry at Wolfsgrove Farm, near Kingsteignton, showed that when fossils occurred, they stood out in relief in the cavities, proving that here at least the phenomena resulted from the action of atmospheric agents, and not that of snails.

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[1] Geol. Mag., Vol. VIII. p. 500. See also Geol. of E. Somerset, etc. (Geol. Survey), p. 26.

[2] Trans. Geol. Soc., 2nd series, vol. v. p. 651.

[3] Idem, vol. vi. pp. 461, 469.

While I would not for a moment suggest that an accurate parallel of the strata could be made on lithological any more than on palæontological grounds alone, yet we cannot overlook the resemblances.

It cannot be doubted, however, that we must be guided by the stratigraphical facts, and most important is the relation that the Devonian Limestone bears to the Culm-Measures above.

While I have indicated the facts of the succession in the strata near Newton Abbot and Torquay, there are many places where the relations of slates and limestones are not clear.

The mass of limestone that extends from Lyndridge to near Kingsteignton dips to the south-east at angles of from 20° to 30°. The boundary-line with the Culm-measures to the north runs along the bottom of the valley, and no junction sections are to be seen. The same is the case south of Ideford, where, instead of there being three small masses of limestone in the midst of the Culm-measures, there is but one mass, abruptly adjoining these newer strata. The Culm-measures at Combe, Heston, and Whiteway Farms dip to the south-east as if they would pass under the Devonian Limestone. Hence, if the beds be not actually inverted, there must be a considerable fault running along the valley between Lyndridge Hill and Ideford. An inversion might help us to account for the mass of limestone stretching from Oldchard Well to Ugbrooke House. Its relations with the Culm-measures are nowhere exhibited, but these beds are seen to be violently disturbed by the high-road west of Bellamarsh Wood; here, however, the great fault that cuts off the Chudleigh Limestone may pass. Again the Devonian slates that extend from Bishopsteignton to Kingsteignton, and which near Wear Cross would seem to overlie the limestone, are nowhere clearly shown in relation to it, and are highly disturbed in places by the great intruded mass of igneous rock. There is clear evidence in the cliffs north of Teignmouth of a fault which runs through Bishopsteignton.

Nowhere have we any positive evidence of a mass of Devonian slates overlying the limestone. In some places, near Oldchard Well and Abbots Kerswell, I have seen traces a foot or two in thickness of blue and purple shales resting upon the limestone, and this would accord with the facts obtained by my colleague Mr. Reid at Chudleigh, where the Devonian Limestone is only separated from the Culm-measures by a thin bed of shales.

This question of the relations of Devonian rocks and Culm-measures is full of interest, and full of puzzles. Authorities agree that the Culm-measures represent a part of the true Coal-measures, and probably include the whole of the Millstone-grit. Both Mr. Godwin-Austen and Dr. Holl have maintained that in South Devon the Culm-measures rest unconformably upon the Devonian rocks. Some of the evidence relied upon by the former, and quoted by the latter, has been shown by Mr. Reid to be the result of a fault;[1] and so far as my own observations have gone, I saw nothing in the relations of Culm-measures and Devonian rocks near Newton

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[1] Paper read before Brit. Assoc. at Plymouth.

Abbot that proved unconformability. And I could only agree with Jukes that concealed disturbances and faults would account for all the phenomena there to be observed.[1]

The promontory of Torquay and Babbacombe Well shows the great disturbances to which the beds have been subjected. The cliffs are for the most part abrupt, and they can only be studied by the aid of a boat. In the quarry at Hope's Nose nearly horizontal beds of limestone may be seen resting on the upturned edges of similar rock, in such a manner that a first glance would seem to show an undoubted case of unconformability. It requires, however, but little examination to prove that this feature is the result of a fault acting on the disturbed beds of limestone, and whose hade is inclined inwards from the face of the quarry. The contortions throughout the Torquay district are very great, and the faults are numerous. In one instance the beds are clearly reversed, as Mr. Champernowne has pointed out.[2]

At Meadfoot are beds of slate and grit which show considerable metamorphism. Some of the large masses strewn along the shore well exhibit the phenomena of cleavage, bedding and jointing. The precise relation of these beds to the limestone is not clear owing to numerous faults, but I think we have in them representatives of the lower portion of the slaty series or the junction beds with the red sandstone group.

Some hard grits that occur near Christ Church, Ellacombe, and near Upton Church, also north of Hope Farm, reminded me of the Millstone-grit.

These notes are scanty, but they may not be without their use. A study of what has been written, and, more important still, the recent field-researches of Mr. Champernowne, indicate that the facts to be obtained near Newton Abbot and Torquay *may* be applicable to the whole of South Devon; and the structure *may* therefore be much simpler than is generally thought, or than the observations of Dr. Holl would lead us to suppose.[3]

Much has been written, and especially by Mr. Etheridge, about the correlation of the beds by fossil evidence; but it is needless to observe that until the stratigraphical relations of the beds have been worked out, the organic remains cannot be taken as evidence for classification. The work of Phillips, which will always be highly valued for its specific identifications, contains few references to the exact horizons from which the species were obtained. Much of the collecting must therefore be done afresh, and here is plenty of work for the resident geologist. We cannot have too many lists of fossils recording the precise beds and localities; for by these means only can we determine the succession of life forms, and arrive at any conclusions as to the geographical distribution of the species.[4]

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[1] Notes on parts of S. Devon, etc., p. 7. See also GEOL. MAG., Dec. II. Vol. III., Oct., 1876.

[2] Trans. Devon. Assoc. for 1874.

[3] Quart. Journ. Geol. Soc., vol. xxiv. p. 400.

[4] I trust that Mr. J. E. Lee may be tempted to publish a catalogue of the Devonian fossils in his collection.

So far as one can judge at present, the evidence certainly favours the views of Jukes, that the basement beds of the Devonian system are truly Old Red Sandstone, while the succeeding slates and limestones were formed during what we call the Lower Carboniferous period, and in a different zoological province to the Mountain Limestone of other parts. The view that the entire series of the Devonian rocks was deposited during the same period as the Old Red Sandstone is entirely unsupported by physical or stratigraphical evidence, for it requires a barrier to have existed at the time, separating a lacustrine from a purely marine area, and of this we have not the slightest evidence. And indeed, just where we should look to find it, we come across the mass of Limestone at Cannington Park, which some observers call Carboniferous Limestone and some Devonian Limestone. Perhaps both views may be right.

VII.—ON THE JUNCTION OF THE LIMESTONE AND CULM-MEASURES NEAR CHUDLEIGH.

By CLEMENT REID, F.G.S.,
of the Geological Survey of England and Wales.

(Communicated by permission of the Director-General of the Geological Survey of the United Kingdom.)

IN the course of an examination of the district around Chudleigh during the year 1875, I was led to consider that there is a passage from the Devonian Limestone into the Culm-measures, and that all the appearances which have been accepted as indicating unconformability may be easily accounted for by a fault with a considerable hade.

The peculiar position of the Chudleigh Limestone has led to many hypotheses in explanation of the manner in which it appears to abut against the Culm-measures. Sir Henry De la Beche, judging from the apparent dip of the Culm-measures beneath the Devonian rocks, considered that the Limestone was included in the Carbonaceous Series, and as such it was engraved in his published sections and coloured in the Geological Survey Map.

Mr. Godwin-Austen and most subsequent writers have recognized the identity of the limestone of Chudleigh with that of Newton Abbot, but have considered that there is evidence of unconformability, and have drawn hypothetical sections in support of this view.

The following fossils, which I collected from the limestone in the neighbourhood of Chudleigh, correspond closely with those to be found near Newton Abbot. The species have been identified by Mr. Etheridge:—

Lower Dunscombe Quarry (upper part of the limestone):

Rhynchonella pugnus, Mart. sp.
,, *cuboides*, Sby.
Atrypa, sp.
,, *reticularis*, Linn. sp.
Streptorhynchus crenistria, Phil.
Fenestella.
Cyrtoceras.

Kerswell Quarry (middle or lower part of the limestone):

Stromatopora.
Cyathophyllum cæspitosum, Goldf.
Favosites cervicornis, Edw.
Heliolites porosa, Goldf.
Alveolites suborbicularis, Lamk.
Pullastra.

Acroculia vetusta, Phil.
Murchisonia angulata, Phil.
„ *spinosa*, Phil.
Natica ?
Euomphalus serpens, Phil.
Macrocheilus ?
Pleurotomaria cirriformis, Sby.

Prof. Phillips and Mr. Jukes suggested the existence of a fault, and a detailed examination of the ground has enabled me to trace a dislocation which will without difficulty account for the apparent unconformability.

Unfortunately sections of the junction of the Culm-measures and Devonian Limestone are rare, but in the road south of Lewell House, near Chudleigh, we have an exposure which has every appearance of a passage. The upper part of the Limestone is seen to become more and more shaly, then to pass into alternations of shale and limestone; and gradually grit, at first fine grained, replaces the calcareous beds. Still higher there is thick-bedded sandstone like that in the lower part of the Culm-measures of Ugbrooke Park. The upper part of this section is not clearly exposed, though it seems to indicate a passage.

At Lower Dunscombe Quarry the Limestone again passes into limestone-shale containing *Clymenia valida* and *C. striata* (as identified by Mr. Etheridge). Unfortunately the junction with the Culm-measures is not exposed; but as far as can be judged from the stones in the adjoining fields, it is similar to that shown in the last section. It is noticeable that the species of *Clymenia* have not been found in the solid limestone, but only in the few feet of calcareous shales above it.

A more difficult question has arisen from the abrupt ending of the Limestone on the west of Chudleigh and its sudden replacement by Culm-measure shales. The small patch at Waddon Barton is nearly horizontal, and entirely surrounded by green and purple Devonian slates; the isolated position of this limestone is caused by denudation, and a slight flexure of the beds will connect it with the main mass. A short distance to the west a fault runs in a north and south direction, throwing down Culm-measures against the slates; this fault I have traced northward to Whiteway House, where the Limestone and Culm Shales are thrown together. The fault then disappears beneath the Triassic rocks of Haldon, apparently without affecting them. To the south the dislocation can be traced to near Lower Herkley, beyond which I have not ventured to continue it, as there are only slates and shales for guidance.

Mr. Godwin-Austen, in his "Geology of the South-east of Devonshire," mentions a well dug at the house on the west side of Chudleigh rock. This showed about fifteen feet of horizontal carbonaceous shales and sandstones resting on highly inclined claret-coloured slates dipping in the same direction as the Chudleigh Limestone. Mr. Austen considers that this is an instance of unconformability; but on quite independent evidence, and before I had noticed the account of this well, I had been led to trace the fault through this exact spot. A considerable hade to the fault will account for all the appearances in this and some other sections noticed by Mr. Austen and Sir Henry De la Beche.

VIII.—GEOLOGY OF THE ISLE OF MAN.

By HENRY H. HOWORTH, Esq.

(*Concluded from page* 413.)

IN my former note I adduced the reasons which make me confident that the conglomerates of the south of the Isle of Man, which have been hitherto classed as Devonian, are not Devonian, but are later than the Carboniferous Period. I will now turn to the problem of what they really are. It is a well-known fact that in the Isle of Man the Secondary and Tertiary rocks are wholly absent. This is the view of all those who have examined the island, and is in fact perfectly palpable. The series of older rocks terminates with the upper layers of the Carboniferous Limestone; above this there are nothing but deposits of Quaternary Age. The red conglomerate to which I have referred contains no trace of any Secondary or Tertiary fossils, nor is there the smallest ground for believing that it belongs to either of those series. Does it then belong to the Quaternary beds? This conclusion is inevitable, and, as we shall see, is an exceedingly interesting one.

The deposits of the Pleistocene age are developed in the Isle of Man on a very large scale, and the series may be there studied in detail, and especially the Boulder-clay formation. One of the peculiarities of the Boulder-clay in the Isle of Man is the large proportion of local or insular materials that have built it up. This has been noticed by Mr. Cumming (*op. cit.* page 113).

Here let me make a small digression. If, as is almost certain, the matrix in which the boulders are imbedded was formed out of the subjacent rocks, ground down and pulverized by moving ice, it is quite clear that what will be clay in one situation, where the materials for making clay exist, will be an entirely different substance elsewhere. That the same sheet of shore-ice, which in scraping over the upturned edges of Silurian schists makes excellent clay, will, within a few yards of the same place, and perfectly contemporaneously, be making a bed of a pasty texture out of the Mountain Limestone immediately adjoining, while if it was ploughing down the surface of Secondary and Tertiary rocks, the resulting product would again be different. I don't know (and claim the privilege of a mere student in suggesting) but it may be that those who have mapped out the Quaternary Deposits of Europe have not sufficiently attended to this crucial fact, namely, that they have looked for Boulder-clay where no clay could possibly be found, and that they have placed on a different horizon some really contemporaneous bed made of different materials.

In the Isle of Man, at all events, we must take this fact into consideration, and we have our lesson very palpably laid down for us. Where the basset edges of the schists are exposed, we find the adjoining drift deposits to be almost pure clay. Where these beds change colour, so do the superincumbent clays. Where we near the horizontal beds of limestone deeply scored in various directions, we find more and more lime in the clay, which becomes a veritable tilth, as my friend Mr. Binney calls it; and lastly, we have beds evidently contemporaneous with and made under precisely the same conditions as the Boulder-clay proper, composed of a kind of soft pudding-stone, of boulders imbedded in a matrix not of clay, but of disintegrated limestone.

The proportion of lime from the clay in various parts of the island is given by Mr. Cumming in Appendix I. of his work, and fully confirms this argument, and, as that author says, "indicate the extremely local character of the contents of a great part of the Boulder-clay." (Ibid. p. 306.)

Let us now turn once more to the red conglomerate. Superficially it will be conceded by those who see it that it resembles an indurated Boulder-clay formation of a red colour. This was, in fact, remarked by Mr. Cumming, who says of it at one place, "It looks extremely like a consolidated ancient Boulder-clay formation, only there is more approach to regular bedding, more regularity of stratification, as in the drift-gravel deposits." (*op. cit.* 8–9.) The word "ancient" in this extract must be accepted as covering Mr. Cumming's theory in regard to the deposit; while as to the regularity of the layers of boulders, this is, I take it, in a great measure imaginary. I noticed no such peculiarity except in very local instances. The red colour I have already explained as resulting from the formation being made up of disintegrated local rocks of an ochreous colour. Where the schists and limestones are not purple, the conglomerate exists without its red colour, and I have specimens by me showing the gradation from a perfectly grey pudding-stone of limestone to one quite russet in colour. The inclosed blocks, as I said in my former paper, consist for the most part of boulders of the adjoining limestone, many with their edges hardly rubbed at all; and the whole deposit, but for its colour and tenacity, is very like the mass of undoubted Boulder-clay forming Hango Hill, in the centre of the Bay of Castletown.

The situation of the conglomerate is also that of a drift deposit. It caps the hills and higher ground, as at the Brough and at Langness Point, and at the latter place may be studied in close proximity to similar deposits without the red colour, which have been described by Mr. Cumming as Boulder-clay. In every sense I believe therefore the red conglomerate to be a glacial deposit, and in no sense a Devonian one; and as such a striking example of the law prevailing among the glacial deposits of the island in "changing in composition and tallying in chemical character as well as in lithological appearance and colour with that of the adjacent rock." (Cumming, *op. cit.* p. 113.)

I have not yet referred to what seems to me the most important result of this rectification, and which indeed induced me to prosecute my inquiry. I have said that the conglomerate differs from an ordinary Boulder-clay deposit in one important respect, namely, in its compactness and solidity. This quality it shares with much of the grey conglomerate with which I have compared it. The cause of this density we must now inquire into. One horn of Castletown Bay is occupied by a famous basaltic boss, known as the Stack of Scarlet. From this boss lines of trap emerge in sporadic fashion and may be traced in various directions, especially about the promontory of Langness, in Derbyhaven Bay, and at Cushnahavin. Where they have burst through, they have naturally altered the rock very considerably. It has in some places so altered the limestone that it is impossible to see any limit where trap ends and limestone begins. In another place, namely, close to Ronaldsway, between high- and low-water mark, it has broken it up into rhomboidal blocks by cracks running S. 40° W. and S. 30° E. But the metamorphism is more important elsewhere. Let me quote the graphic words of Mr. Cumming himself:

"There is one remarkable fact which should not be overlooked, which is, that the Boulder-clay itself seems in some measure to have partaken of the metamorphosed character of the limestone. Patches of it here and there are hardened and cemented, and present a baked appearance, and have resisted the action of the sea. It is difficult to determine whether this has resulted from long contact with the ochreous mass of altered limestone, or from the escape of heated gases at some period of the Boulder-clay through cracks formed by the previous disturbances which we must thence class as belonging to the Boulder period." (*op. cit.* p. 100.) The difficulty suggested by Mr. Cumming exists only so far as I can see because of his classing the red conglomerate as Devonian. If he had seen that it was in fact but an altered glacial deposit, but one conclusion would, it seems to me, have been possible. Let me, to illustrate my position, quote one more passage, and although a long one, it shall be the last. Speaking of the great trap dyke at Langness, Mr. Cumming says:—"The ground plan of it is well worthy of a minute study, and the contrast of colour of the two rocks (the green or olive-coloured trap and the red conglomerate) renders the phenomena distinctly visible to even an ungeological eye. The trap seems to shoot out in one strong body from the schist to the eastward, and may be seen as a dyke of the breadth of forty-five feet, where it runs out to sea, on the eastern side of the peninsula; but as soon as it enters upon the old red conglomerate (*sic*) which overlies the schist, we find it separating into branches and twisting about amongst the pebbles and boulders of that formation in a most singular manner. Some of these branches taper off to an extreme thinness. We can trace them by the colour till they are scarcely the thickness of a wafer. Now on the opposite side of the bay, at Knockrushen, we see this dyke where it cuts through the limestone in the same solid and compact form which it has where it cuts through the schist. There are there to be sure two or three straight cracks in the limestone, which have been filled up by the fluid trap injected from this dyke; but the general fact which we must observe is this, that in the schist and tough limestone the trap dyke is compact; in the old red conglomerate it is spread out and branching. And thus we come to the conclusion that the fluid trap was forced [illegible]rds with enormous force through the schist; that when on its ascent it reached the more permeable and separable beds of the old red conglomerate, tied down as they are by the tougher masses of limestone, it spread itself out and ultimately raising the limestone in a boss or saddle, produced a crack or series of cracks, and so forced its way through the opening to the surface." With this passage as a description of facts I do not quarrel; but I cannot at all agree with its inferences. If the conglomerate was of Devonian age, as Mr. Cumming suggests, and the trap dyke in passing through it was broken up into many small channels, it seems impossible that it should have again become concentrated into one or two main streams in passing the limestone. But if the conglomerate be as I claim to have shown, of Glacial age and long posterior in date to the limestone, the appearances so truthfully and graphically described by Mr. Cumming are at once clear and very interesting. The streams of trap permeating the red conglomerate make it almost certain that the outbursts of the trap and the activity of the volcanic vent at Scarlet Point were posterior to the deposit of the Boulder-clay, and we thus add another remarkable example to the list of volcanos active within the British seas in post-Tertiary times. Although only an amateur geologist, I hope this may be deemed a fact of sufficient importance to excuse my intrusion into your pages.

IX.—ACROSS EUROPE AND ASIA.—TRAVELLING NOTES.

By Professor JOHN MILNE, F.G.S.;
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(Continued from p. 406.)

Part V.—Ekaterinburg to Tomsk.

CONTENTS.—Ekaterinburg to Tumen.—Tumen to Tomsk (along the Toufa, Tobol, Irtish, and Obi).—The Ostiacks.—Character of the Siberian Steppes.—Theory of their Origin.

ON Wednesday, the 22nd of September, I left Ekaterinburg for Tumen, where I hoped to catch a steamer going to Tomsk. For a short distance after starting, the road was bounded by tall firs. Beyond these came a few hill-like mounds covered with large grey weather-worn boulders, the appearances of which were not unlike those of some ancient terminal moraines. These boulders were the only ones which I saw during the whole of my journey across Siberia. From their similarity to the rock of the country which here and there cropped up through its covering of peat and grass, I think they must have been of local origin; but whether this origin was in any way connected with the action of ice, through not having made any close examination I am unable to form any conclusion. For the remainder of the road the land on either side was under cultivation, and was yellow with fields of stubble and stacks of corn. Now and then I passed a village of log huts. In each of these a church, with a towering dome, surrounded by many smaller domes, was conspicuous among the poverty above which it rose. At many of the houses in the villages of this part of Siberia the inhabitants had been at some pains in building small box-like houses, which were raised on the top of poles, in order to induce sparrows to localize themselves.

Along the roads there were numbers of birds like magpies, water-wagtails, and woodpeckers, but these were perhaps not so desirable as the sparrows. After 36 hours of continuous travelling, I reached Tumen, the distance being $306\frac{1}{4}$ versts.

At Tumen there are some engineering works, which belong to Mr. Wardroper, an English resident, who has made many of the steamers of light draught which are now so numerous on some of the Siberian rivers. The evening after my arrival I joined a small steamer which was to take us down the shallower portions of the River Toufa to a larger steamer lying further down. Upon the right hand, or southern side of the river, there is a bank from 50 to 80 feet in height, which is chiefly composed of white sand. The opposite shore is however low. As we descended the river, these appearances were reversed, and the high bank was upon the left-hand side. The Toufa is a shallow sandy river, with a very winding course. Lines of willows, which clothed the furrowed banks on either side, shut out our view of the surrounding country.

Our progress was both slow and difficult, but this was partly owing to our steamer having to tow behind it a large and unwieldy barge, in which there were nearly 1000 convicts. Now and then we obtained a glimpse through the barrier of willow on either side, and saw a background of tall black firs and the flickering leaves of clumps of aspen. On this river, although we were many hundreds, and I might almost say thousands of miles from the sea, there are many sea-gulls (*Larus canus ?*) to be seen. The backs of these were grey and the ends of their wings black.

Early on the morning of the 26th September we left the Toufa river and joined the Tobol. The water was still of the same dirty which trends across the country like some huge embankment. Further to the north this ridge forms the eastern bank of the river; but on reaching the point at which Tobolsk is situated, it turns suddenly and bears away almost at right angles to its previous direction. It is in fact an abrupt termination to a plateau, on the top of which one portion of Tobolsk is built, whilst the other portion of the town is below.. Whilst we were still at a distance, many church spires, white barracks, and various public buildings could be distinctly seen. As we neared these, we left the muddy waters of the Tobol, and joined the clear black waters of the Irtish. As we had a few hours' rest at Tobolsk, I had opportunity for seeing the town. One thing I soon observed was that stone was a substance which was only known in name, and wood took its place even on the pavement. A steeply sloping deep cutting connected the lower part of the town with the upper part, which is on the summit of the plateau. This, like the streets, was covered with wood. Excepting at this cutting, and at another point where stairs have been built, the scarp-like face of the plateau is too steep to be ascended. Everywhere in the vicinity of the town this scarp consists of a whitish-grey sand. In the upper part of the town, in some public gardens, I saw a monument erected to the memory of Yermack, the first invader and so-called conqueror of Siberia. Another curiosity on the top of the hill was one of the monuments of folly which John the Terrible left standing behind him. This is a bell which, on the occasion of one of his human butcheries, was either ringing when it ought not to have rung, or else was not ringing when it should have done. For this it suffered exileship instead of those who had thus misused it, and after having a small piece broken from it, was sent to Siberia with orders that never so long as it was a bell, was it to ring again.

After looking at the lower portion of the town, where the greater part of the business is transacted, we rejoined the steamer, and were again under weigh steaming rapidly down the Irtish towards its confluence with the Obi. From this point we now had upon our right hand or eastern side the steep slope of what I will call the Tobolsk plateau. This was, however, not quite so high as it was at Tobolsk, and in places perhaps not more than 100 feet. Near its base bluish clayey beds sometimes cropped up. As we continued northwards, villages became fewer, and it soon became a matter of interest even when we saw either a small boat or a man. On our right we had the steep earth cliffs capped with a line of fir, whilst on our left were banks of willows, and a fringe of tall straight grass. As we continued to descend, the river increased in breadth, which, on the 28th of the month, must have been at least a quarter of a mile wide. On the eastern side, we passed the entrances to many lagoon-like areas, filled with water. These I believe were in many cases openings across the bends in the river. Now and then we stopped and hauled in alongside the bank to obtain firewood. This was generally done in the vicinity of a small village, the dirty inhabitants of which, shivering in their tattered sheepskins, giving us some assistance. At these places I had opportunity to examine the banks of the river, which were in fact sections of the great alluvial plain of this portion of Siberia. These sections, which are generally made up of fine sand, now contained in addition some bands of a bluish clay. This clay, which was very slippery to walk on, and plastic in its nature, could be often seen to merge into the sandy beds amongst which it was intercalated.

On the 29th I was told that we had entered the Obi. For some time a dense fog prevented me from seeing where we were. One thing was, however, certain—that we now had a strong current running in a contrary direction to that in which we were steaming. When the mist cleared, I saw myself in a stream about three-quarters of a mile in breadth, bounded by banks ten to fourteen feet in height. On the 30th we drew up to take in wood near the village of Soorgoot (or Surgut), the position of which was indicated by a church tower a few miles distant. Here I saw a number of Ostiacks, who came with boat loads of fish to try and trade. Some of the fish they had were like small pike, and called "stchooke" (*Esox lucius*). These were from three to six lbs. in weight. Others they had were called "nalym" (*Lota vulgaris.*)

The Ostiacks, whom I frequently saw during several succeeding days, were short in stature, had large heads, heavy bodies, and thin legs. Their eyes, which point inwards and downwards, are not deeply sunk in their heads, but are so placed that the eyelids run smoothly up to the eyebrows, which latter are well up above the eyes themselves. Notwithstanding a general chubbiness in their face, the cheek-bones are very prominent. Their hair is long and black, and their complexion chocolate.

Their canoes or boats, in which they swarmed round our ship, were, from their graceful appearance and lightness, very striking. They are cut from a solid block of wood, which I think is a kind of poplar, the Russian name of which is "oseena." Both stem and stern are sharply pointed, and they sweep elegantly from end to end. A midship section is nearly semicircular, but at either end it would be V-shaped. The sides are kept from shrinking inwards by means of two or three transverse stretchers. One small canoe which I measured was ten feet long, one foot nine inches broad, and nine inches deep in the centre. It was so light that I could lift it and carry it easily with one hand. The paddles look somewhat like spades, there being at one end a large flat blade, and at the other a transverse handle. These are only used on one side of the boat.

The dresses of these people, such as they were, were made of sheepskin, and of a coarse brown material like sacking. It was, however, difficult to ascertain their real nature, they were so very dirty. At one of our landing places I saw several of the houses in which these people live. One which I examined was about twelve feet square, with perpendicular walls about three feet high. From two of the side walls there was a sloping roof, meeting in a ridge running from back to front, making the highest point in the house only five feet eight inches in height. The framework of this edifice was made of rough pine sticks. These were stuck in the ground, and over them a covering of birch bark was laid, which was kept in its place by a second row of sticks. The roof was covered in a manner similar to that in which the sides were covered, there being, so to speak, two rows of rafters with birch bark in between them. Along the line of the ridge-pole a long narrow opening is left for the purpose of allowing the smoke from the interior to escape. Some of the birch bark was doubled and sewn together to form sheets six feet square. Along the edge of these sheets an extra strip of bark was doubled over and stitched on as a border, for the purpose, I presume, of preventing any splitting taking place. Many of the utensils in the house were also made of birch bark. With the exception of this method of using bark, and also the neatness exhibited in the building of boats, so far as I saw, the remainder of their works were coarse, clumsy, and untidy.

This portion of the Obi appears to form their southern boundary, and in it they have their capital called Narim.

In many places along the borders of the river there were peaty marshes, covered with moss and occasionally with trees.

Thus far along these rivers I do not remember seeing a single pebble or stone, the only hard substance which I could pick up being a few small nodules of sand cemented together by iron. Everywhere the banks showed sections of sand, sandy-mud, and a bluish clay, the sand, however, always predominating. As we passed small creeks which masked the mouths of tributary streams, the beds of sand were usually capped with beds of mud, which had probably been deposited by the stream which now ran over them.

On the 4th of October we stopped at a place called Kolpashovoe. At this place one bank of the river forms cliffs 70 to 80 feet in height. These cliffs are nearly wholly composed of white sand, but near their base they suddenly merge into a bluish clay. In the lower part of these clayey beds I saw some fine lines of black earthy matter from $\frac{1}{8}$ to $\frac{1}{4}$ inch in thickness. An examination of these showed them to consist of yellowish green particles of vegetable matter resembling a flat-leaved grass.

Next day, the 5th of October, we reached the mouth of the river Tom. As this river was very shallow, we had to leave our large steamer and join a smaller one. Along the shore there were many bushy trees, on which a few autumnal leaves yet fluttered. Beyond these trees came an open flat country. In all places the water of the river was rippling and eddying along with a current that proved itself far too strong for our little steamer and the bargeload of convicts which we had to tow behind us.

The bottom, like the shores on either side, was pebbly, whilst the water, unlike that of the Obi, was quite clear.

On several points along the shore, and noticeably along those parts where the water rises and falls slowly, there was a red deposit of iron. Upon those parts up to which the waters rapidly reached and afterwards rapidly receded from, as would happen during flood times, no deposit had been formed. On the evening of the 5th, it was warm enough to go outside without an overcoat; but next morning, as we sighted Tomsk, it was bitterly cold, and our decks were thickly covered with ice. The time at which the Tom generally becomes frozen is about the 22nd of October, and it then remains closed until about the 20th of April.

Before proceeding with a description of the country which I saw beyond Tomsk, I will give my impressions of the vast plain through which, since leaving Tumen, I had been traversing. One great feature was the absence of variety, in consequence of which my daily observations became almost a series of identities,—everywhere there was one great plain composed of either sand or loam forming more or less of an open Steppe.

The origin of these Steppes, according to Mr. Thomas Belt and Siberian geologists, was due to the blocking up of the mouths of the great Siberian rivers by an overflow of polar ice from the north, and a consequent flooding of the country by an overflow of the rivers in the south. Mr. Belt chiefly bases this view on observations made by him when on a journey from Ekaterinburg to Byanovl, 360 miles S.E. from Omsk.

One observation which was apparently very quickly made was, "that the plains had no relation to the present river-system; the rivers simply cut through them; and there are no defined river-basins bounded by rocks of greater age on which they might have been deposited."

This simple but grand method of dealing with the river-systems of Northern Asia and their boundaries, which are but little better explored than the sources of the Nile, is not, I think, in all senses justifiable; for if we take any Physical Map of Asia, we shall see that the river-systems form a remarkable example of the connexion of rivers and plains, which can be only paralleled on the Amazons. Wherever there is a river, and especially a large one, a broad plain accompanies it for the greater portion of its course. As it expands in flowing north, the plain also expands. The widening of these plains continues until they touch each other, when they unite to form that open flat expanse which fringes the Arctic Ocean.

That every river has a tongue of flat ground through which it runs is a fact which points to the intimate connexion of the two (plain and river). Such a fact as this assists in making Mr. Belt's argument more comprehensible; for, instead of being led to regard the whole of Northern Siberia as having been one huge freshwater lake, the area of which would be unparalleled, it might now be regarded as several areas, each occupying more or less its own particular basin.

The most important point about these plains is the immense expanse of sand and loam which they everywhere exhibit. The absence of marine shells and the presence of freshwater shells like *Cyrena fluminalis* over a great portion of the area furnish strong evidence, which Mr. Belt brought forward in support of his argument, that these strata were deposited in fresh rather than in salt water. As additional evidence to these conclusions, I may add from my observations, first, the finding of plant-remains on the Obi at Kolpashovoe, and, secondly, the fact that the sand and loam when examined microscopically show a sharp angularity, characteristic of river-sand rather than of those sands which had been washed and rounded in the sea. The samples of sand and loam which I collected came from districts far apart, and therefore may be taken as representing the character of an area rather than that of a single spot.

As culminating evidence in support of this theory, Mr. Belt seems to have found, at Pavlodav, "the ancient bed-rock over which the ice must have moved if it existed, and saw the crushed and shattered surface and the fragments pushed up into the overlying silt." Now this is an interesting discovery, because it is so strange that Mr. Belt in his flying visit should have been so fortunate as to have met with the remains of glacier action, whereas geologists who have been working in these latitudes of Siberia, especially near Irkutsk. for the last ten years, where glaciers were *more* likely to have occurred if an ice-sheet ever advanced so far as Mr. Belt supposes, have not yet been able to find any signs of ice-action greater than those which are annually produced by the freezing of the river.

Also, if such a cold period had existed, ice-rafts must have scoured the sides of this great lake, and carried off boulders from its shores to deposit them on its bed. But ice-markings, such as are produced upon every coast invaded by floating-ice, I have not seen nor heard of, neither are the boulders to be found,—the country is, in fact, as I have pointed out, singularly destitute of stones, and whilst travelling more than 1500 miles in parts where I had many opportunities of seeing sections, I do not remember seeing even a single pebble, although I looked for them. Erman noticed large fragments of rock imbedded in clay at Samarova, but they are probably not very numerous, as I passed through that district without observing them.

Until the markings of old glaciers and coast-ice, together with erratic boulders and allied phenomena, which would be necessary adjuncts to the invasion of a polar ice-cap, and the formation of an inland sea, are shown really to exist, or else have some explanation found for their absence, it would, I think, be better to pause before accepting the idea of an invading ice-cap. Mr. Campbell, the well-known author of "Frost and Fire," argues that if polar ice-caps ever existed, their markings ought to be found in all meridians alike, and that they should approximately be so appears to be a reasonable argument. What is more, if we follow out such an argument as that of Mr. Croll, who shows us that in bygone times there was a glacial period produced in that hemisphere whose winter occurred in aphelion indirectly, owing to its having been at that time further from the sun than it is at present, we must remember that the same series of induced causes would also produce a general lowering of temperature over that half of the world whose crown had been capped by ice. This being the case, glaciers and other forms of ice existing in latitudes below the crown of ice ought to have been considerably augmented, whilst at other points still more removed new ones might be born. Not overlooking the observations of Professor Agassiz on the Amazons, and those of Mr. Belt in Nicaragua, evidences of this kind are yet very rare. As additional reasons for not forming too hasty a conclusion, we must wait until the markings of the ice-cap have been shown to be more general in their distribution, and the markings which would be consequent on such a covering have been more fully recognized. Cosmical changes have no doubt produced their effect upon climate, and so also have causes like those we now see in action, and therefore I do not see the necessity that all glacial phenomena should be attributed wholly to the one or to the other cause; but I must confess that where it is possible to adopt existing agencies, I should take them into consideration before those whose origin and subsequent mode of action was of a more debatable character. For these reasons, together with the fact that the Siberian Steppes present phenomena not well explained by the invasion of a polar ice-cap, I venture to suggest a modification of the theory advocated by Mr. Belt and Siberian geologists, which appears to me to be more reconcilable with the phenomena which have been hitherto recorded.

In addition to the general freshwater character of the plains which has been already noticed, we must also observe the slight elevation which they have above the Northern Ocean towards which their rivers flow. On physical maps points more than 1000 miles inland are shown not to be more than 250 feet above it. Another point to be observed is that the last movement which these plains have made, as indicated by beds of marine shells along their northern frontier, has been an upward one. From this we may infer that when they were at lower levels a considerable portion of their surface must have been covered by what would now be an invading sea. At such a time the rivers would be shorter in length, and the plains, through which they flow, more tongue-like in their character. Again, we must observe that in old times, as at the present day, these rivers were often covered with ice, which, blocking up their channels, may have given rise to floods. These actions can now be seen both at the forming and the breaking up of these winter barriers. By comparison with what has happened in Europe and in America, we may infer that either cosmical or geographical changes, or perhaps both, have in former times intensified this action.

The following table, which I have compiled from information collected when in Siberia, will show APPROXIMATELY the time of formation and breaking up of ice at different latitudes upon the same and different North Asian rivers, and will indicate an important cause operating in the formation of these floods or temporary lakes:

The first thing that will be observed in this table is that the influence of latitude practically outweighs all local circumstances which might accelerate or retard the time of freezing, or the breaking up of the ice upon these rivers. The farther north a place is, the sooner the water freezes, and the later is the ice broken up, as compared with more southern positions. Another point to be noticed

	Name of River.	N. Lat.	Ice Forms.	Ice breaks up.
Basin of the Obi.	Sir Daria, near Aral.	45° 0′	Nov. 20	March 22.
	Obi, near Barnaul.	53° 14′	Oct. 30	April 15.
	Tobol, near Kurgan.	55° 32′	Oct. 26	April 15.
	Irtish, near Tobolsk.	58° 20′	Oct. 24	April 20.
	Obi, near Obdorsk.	67° 28′	Oct. 20	May 20.
Basin of the Yenisei.	Angara, near Irkutsk.	52° 20′	Dec. 30	May 20.
	Lake Baikal.*	53° 0′	Dec. 23	April 20—May 10.
	Yenisei, near Krasnoiarsk.	56° 6′	Oct. 29	April 20.
Basin of the Lena.	Lena, near Kirensk.	57° 40′	Oct. 25	April 30.
	Lena, near Yakutsk.	61° 58′	Oct. 21	May 13.
Basin of the Yana.	Yana, near Ust Yansk.	71° 23′	Sept. 6	May 24.

* Lake Baikal, which is introduced amongst the table of rivers, like the rapid Angara which flows from it, is very irregular in its time of freezing and in opening. These times also vary in different parts of the lake, as might be expected from its north and south extension.

is that on the same river, the northern portion of the river freezes only a little earlier than the southern part, whilst it, comparatively speaking, breaks up a considerable time later. Thus, for instance, on the Obi, at Obdorsk, near its mouth, the ice only forms about one week before it does at Barnaul, which is a considerable distance to the south, whilst it breaks up a month later.

For illustration, suppose we take the River Nile near its mouth, and partially reduce the area of its channel with a blockade of ice for a week: I think we might reasonably expect a flood. Floods of this kind may be observed in low latitudes, as on the Angara near Irkutsk. In 1870, a sudden frost rapidly freezing the river over, a flood was caused which did great damage to the town. But this is not the worst aspect of the action which may be illustrated by taking the Nile, not at an ordinary season, but at the time when it is draining off an unusually large quantity of water from the south, and at such a time placing a barrier across its mouth, not for one week, but for three or four. The consequences would be, I think, disastrous. It will be observed that it is at these times when the Siberian rivers have the most water, from the melting of the southern ice and snow, to drain away, that their mouths are for the longest period dammed up.

During past times, when the cold was probably more intense, these barriers of ice may have been more continuous and complete, and thus have kept the plains—which were then smaller than they are at present, because their northern ends were beneath the sea—more or less constantly covered with a lake of turbid water. As this flood varied in its nature, being more or less dependent upon the accumulation and breaking up of the ice, so we had beds of a varying nature deposited; sometimes they were of silt, and sometimes they were of sand.

And in this way, whilst accepting the main feature in Mr. Belt's argument that it was a barrier of ice which caused a freshwater lake, I should endeavour to explain the origin of the Siberian Steppes, without seeking the aid of a Polar Ice Cap.

We have now a Palæocrystic Ice Cap upon our northern hemisphere, which is small, and placed somewhat jauntily on one side. At one time it was in all probability much larger, and was then drawn farther down over our northern regions than it is at present; but so far as I have seen, many of the markings it may then have made can also be explained by more modest assumptions; whilst not only its tracks, but also of the allies it would have summoned into being, we yet need proof of their existence.

Various causes as at present have in past times been in action, and the results of one may often have obliterated those of others, which renders the tracing of phenomena to their origin a matter of difficulty, because our data are either antagonistic or else not sufficiently convergent in their character.

(To be continued in our next Number.)

NOTICES OF MEMOIRS.

I.—On the Discovery of a Land-plant in the Middle Portion of the Silurian Strata. By M. G. de Saporta. (Comptes Rendus de l'Académie des Sciences, tom. lxxxv. No. 10.)

THE discovery that I am about to announce to the Academy is quite new. On my journey to Caen, three days ago, I received from Prof. Morière, a slab, coming from the slaty-schists of Angers, and from the zone of *Calymene Tristani*, which furnishes evident traces of a tolerably large fern. The impression is in a fair state of preservation; the vegetable substance is replaced by sulphuret of iron, and many of the outlines are broken or torn, as if the plant had suffered from a long sojourn at the bottom of the waters. A very rarely it is true, from near the base of the Silurian strata. These observations agree with those I have just offered to the Academy, and support the conclusions to which I have arrived. I only wish to establish in favour of M. Lesquereux the right of priority which no one will dispute with him. B. B. W.

II.—DESCRIZIONE DEGLI STRATI PLIOCENICA DEI DINTORNI DI SIENA. By Prof. CARLO STEFANI. (Bolletino del R. Comitato Geologico, August, 1877.)

IN the August number of the Bolletino del R. Comitato Geologico Prof. Carlo Stefani completes the "Descrizione degli strati Pliocenica dei dintorni di Siena," which was begun in the previous number. Targioni, Soldani, Pareto, Mortillet, Capellini, and many other Italians and foreigners, who have made a study of the Tertiaries, have described this district, which makes a detailed description and discussion of the geology of this classical spot, brought up to the present stand-point of the science, doubly important. The beds in the immediate neighbourhood are Pliocene, apparently lower and middle, consisting of alternations of marine and brackish-water strata, with fresh-water only in one place, and these changes the author ascribes to the amount of sea-water which could enter into a gulf of the sea in this locality.

The great development of the Pliocene in Italy and contemporaneous deposits having taken place in such different circumstances, as in deep-sea, littoral, brackish, and fresh-water conditions, it is not unnatural that many divisions of this period have been made which will have to fall under more exact examination, and in the Siena beds Prof. Stefani shows that the geological phenomena become simpler when the contemporaneity of the various deposits is understood. Long lists of fossils are given for comparison, and a complete catalogue from the pen of a colleague is promised shortly. These beds, it is unnecessary to say, are very fossiliferous.

The laborious communications that are constantly appearing in this Bolletino on the interesting Miocene and Pliocene formations of Italy are gradually placing before us the recent geology of this country with great clearness. A. W. W.

III.—ABSTRACT OF A PAPER ON THE CARBONIFEROUS LIMESTONE AND MILLSTONE-GRIT IN THE COUNTRY AROUND LLANGOLLEN, NORTH WALES. By GEORGE H. MORTON, F.R.S.

[Read at the Meeting of the British Association, Plymouth, August 20th, 1877.]

THE author described the Carboniferous Limestone exposed in the Eglwyseg ridge near Llangollen. He stated that the finest section is exposed at the Ty-nant ravine, on the west of Cefn-y-Fedw, and that the country must be considered as the typical area of the Lower Carboniferous series in North Wales. The Millstone-grit, or Cefn-y-Fedw Sandstone, which reposes on the limestone, in the same district was also described. The following tabulation explains the succession and thickness of the entire series.

TABULAR VIEW OF THE CARBONIFEROUS LIMESTONE AND CEFN-Y-FEDW SANDSTONE IN THE COUNTY AROUND LLANGOLLEN.

		Feet.	
CEFN-Y-FEDW SANDSTONE.	Aqueduct Grit, or Upper Sandstone and Conglomerate	70	Upper Cefn-y-Fedw, Dee Bridge, or Millstone-grit Series.
	Upper Shale	30	
	Dee Bridge Sandstone	30	
	Lower Shale with Fire-clay and bands of Limestone	18	Middle and Lower Cefn-y-Fedw, or Yoredale Series.
	Middle Sandstone	200	
	Cherty Shale	50	
	Lower Sandstone and Conglomerate	250	
	Sandy Limestone	75	
CARBONIFEROUS LIMESTONE.	Upper Grey Limestone	300	Upper Carboniferous Limestone.
	„ White „	300	
	Lower „ „	120	Lower ditto.
	„ Brown „	480	
		1923	

Upper Old Red Sandstone ..... 300 feet.

Each of the subdivisions was separately described, and a section from the Ty-nant ravine to Tyfyn-uchaf was exhibited, showing the regular succession of the whole of the strata from the Old Red Sandstone to the Coal-measures. The following table shows the gradual attenuation of the Carboniferous Limestone towards the south-east.

SUBDIVISIONS.	Ty-nant.	Tan-y-Castell.	Trevor Rocks.	Bronheulog.	Fron.
Upper Grey Limestone	300	300	250	66*	88*
„ White „	300	250	140	99	27†
Lower „ „	120	115	117	104	—
„ Brown „	480	360	100‡	26‡	—
	1200	1025	607	295	115

* Upper portion has been denuded.
† Reposes on the Wenlock Shale.
‡ Lowest beds not ascertained with certainty.

This section shows how the limestone diminishes in thickness with the rise of the Wenlock Shale towards the south-east. Between the Ty-nant ravine and Fron, four miles from the former place, the attenuation is not less than 900 feet.

The list of fossils collected by the author contained seventy-seven species. Of these fifty-eight occur in the Upper Grey Limestone, and only eighteen in the Lower Brown Limestone. If the Carboniferous Limestone is simply divided into Upper and Lower Limestone, thirty-eight species are peculiar to the two upper subdivisions, and nineteen to the two lower subdivisions; twenty species being common to both. However, the species are by no means confined to the subdivisions in which they are found near Llangollen, for they occur at different horizons in other districts.

IV.—British Association for the Advancement of Science, Forty-seventh Meeting, Plymouth, August 16th, 1877. Titles of Papers Read in Section C. (Geology).

President.—W. Pengelly, Esq., F.R.S., F.G.S.

President's Address. (See p. 419.)

The President.—Sketch of the Geology of the Coast from the Rame Head to the Bolt Tail.

J. H. Collins.—On the Drift of Plymouth Hoe.

R. N. Worth.—Notes on the Palæontology of Plymouth.

Professor G. Dewalque.—On the Devonian System in England and in Belgium.

A. Champernowne, M.A.—On the Succession of the Palæozoic Deposits of South Devon.

S. R. Pattison.—On the Carboniferous Coast-Line of North Cornwall.

C. Reid.—On the Junction of the Limestone and Culm-measures near Chudleigh. (See p. 454.)

H. B. Woodward.—Notes on the Devonian Rocks near Newton Abbot and Torquay, with Remarks on the Subject of their Classification. (See p. 447.)

W. Pengelly, F.R.S.—Thirteenth Annual Report of the Committee for assisting in the Exploration of Kent's Cavern.

R. H. Tiddeman, M.A., F.G.S.—Fifth Annual Report of the Committee for assisting in the Exploration of the Settle Caves (Victoria Cave).

C. De Rance, F.G.S.—Report of the Committee for investigating the Circulation of Underground Waters in the New Red Sandstone and Permian formations.

C. Le Neve Foster, D.Sc., F.G.S.—On some Tin Mines in the parish of Wendron, Cornwall.

C. Le Neve Foster, D.Sc., F.G.S.—On the "Great Flat Lode" South of Redruth and Camborne.

C. Le Neve Foster, D.Sc.—On some of the Stockworks of Cornwall.

Arthur W. Waters, F.G.S.—Influence of the Distribution of Land and Water upon the Shifting of the Axis of the Earth.

J. H. Collins, F.G.S.—Note on the Serpentine of Duporth in St. Austell Bay, Cornwall.

Professor J. W. Clarke.—Some Observations upon the Origin and Antiquity of the Mounds of Arkansas, United States.

Professor A. S. Herschel, M.A., F.R.A.S., and *G. A. Lebour, F.G.S.*—Report on the Thermal Conductivities of Rocks.

Rev. H. W. Crosskey, F.G.S.—Report of the Boulder Committee.

J. Gwyn Jeffreys, LL.D., F.R.S.—On the Post-Tertiary Fossils procured in the late Arctic Expedition, with Notes on some of the Recent or Living Mollusca from the same Expedition.

C. E. De Rance, F.G.S.—Note on the Correlation of certain Post-Glacial Deposits in West Lancashire.

G. H. Morton, F.G.S.—On the Carboniferous Limestone and Millstone-grit in the Country around Llangollen, North Wales. (See p. 469.)

G. A. Lebour, F.G.S.—On some Pebbles in Shales.

W. Gunn, F.G.S.—A Short Sketch of the finding of Silurian Rocks in Teesdale.

W. Molyneux, F.G.S.—On the Occurrence of ***Aviculopecten*** and other Marine Shells in Deposits associated with Seams of Coal, containing Salt Water, in the Ashby Coal-field.

H. C. Sorby, F.G.S.—On a New Method for Studying the Optical Characters of Minerals.

Rev. Professor Heer.—Note on the Fossil Flora of the Arctic Regions.

H. Woodward, F.R.S.—On the Discovery of ***Branchipus*** in a fossil state in the Eocene Limestone (Freshwater) of Gurnet Bay, Isle of Wight.

G. A. Lebour. F.G.S.—On the Age of the Cheviots.

R. A. C. Godwin-Austen, F.R.S.—On the Geological Significance of the Boring at Messrs. Meux's Brewery, London. (See p. 474.)

Thomas Plunkett.—Cave Exploration in Fermanagh.

Dr. J. S. Phené.—On some peculiar Stalactitic Formations from the Island of Antiparos.

A. J. Mott.—On the Source and Function of Carbon in the Crust of the Earth.

REVIEWS.

I.—THE AMERICAN PALÆOZOIC FOSSILS. A CATALOGUE OF THE GENERA AND SPECIES; WITH AN INTRODUCTION DEVOTED TO THE STRATIGRAPHICAL GEOLOGY OF THE PALÆOZOIC ROCKS. By S. A. Miller. (Cincinnati, Ohio, 1877.)

THE constant additions to the number of fossil species, and their publication in different memoirs and various kinds of periodicals, renders it very difficult for the student of palæontology to ascertain with a view of giving assistance to palæontological students and workers, in avoiding errors and improving the nomenclature of the science. Most of us must admit that much confusion exists in the scientific nomenclature, as regards scientific and grammatical errors. Synonymy is frequently overburthened by the impossibility of learning where species have been found, or what names have been given; besides which, many names have been formed in violation of the recognized rules of language. On this latter point some errors are pointed out, and useful rules are given for the formation of new names in palæontology, and thus avoid the occurrence of malformed words and barbarous terms, some of which, too long current to be now withdrawn from circulation, will serve as memorials, fossil relics, to show to future times the freaks of linguistic development in the early days of Palæontology.

The introduction which follows is devoted to stratigraphical geology, and the author gives a concise account of the successive geological formations and their equivalents in North America, from the Archæan to the Permian inclusive, with an estimated thickness of 28 miles, all of which is known to be fossiliferous, except about three miles at the base. In the Catalogue, which occupies more than 200 pages of the work, the genera and species are arranged in alphabetical order under the following great divisions, Plantæ, Protista, Radiata, Mollusca, Articulata, and Vertebrata; the subkingdoms are again divided into classes, orders, and families; so that the zoological position of the genera mentioned in the different lists may be found. The mode of arrangement is simple but useful, the names of the authors, dates, place of publication, groups of rocks in which the species are found, are given, as well as the etymology and signification of the words, as in the following:

CALYMENE, Brong. 1822, Hist. Nat. Crust. Foss. [Ety. *Kekalymenos* concealed]
Blumenbachii, Brong. 1822, Hist. Nat. Crust. Foss. Niagara group [Ety. proper name].

By this publication Mr. Miller has conferred a benefit on geologists, in showing the nature and extent of the North American fauna, and thus enabling them more readily to compare it with that of Europe. J. M.

II.—REVUE DE GÉOLOGIE, POUR LES ANNÉES 1874 ET 1875. Par MM. DELESSE ET DE LAPPARENT. (Paris, 1877.)

THE publication of the thirteenth volume of the French Geological Record contains the progress of Geology and the allied sciences for the years 1874–75, as shown by numerous papers and books published during that period, and of the contents of which fair and useful abstracts are given. Independently, however, of published works, the editors of the "Revue" have further rendered their work more valuable by notices of the maps and unpublished documents shown in the International Exhibition of Geography at Paris, and by the insertion of numerous private communications from French and other geologists. Besides these, many analyses of rocks are given, which have been made either in private laboratories or in those of the School of Mines or other public institutions, and also notices of all the new researches on the metamorphism and modifications of rocks. The work is compiled with the same care as the previous volumes, and reflects much credit on the pains taken in rendering in a condensed form the notices and abstracts so very useful and instructive; for, without this aid, it would be impossible for any ordinary student to become acquainted with the wide range of geological literature. The subjects are systematically arranged under lithological, historical, geographical, and dynamical geology, besides notices of general works on the subject. Some attention is also given to memoirs on economic geology, and a neatly-executed coloured map is given by M. Delesse. This map, designed M. As. Babinski, although on a small scale, shows in a simple and striking manner the agricultural resources of France, and the relative values of the different districts, and the distribution of the vineyards, commons, and forests. J. M.

REPORTS AND PROCEEDINGS.

"On the Geological Significance of the Boring at Messrs. Meux's Brewery, London." By Robert A. C. Godwin-Austen, F.R.S., V.P.G.S., etc. Read before the British Association at Plymouth (Section C.).

The author commenced by pointing out that it was very generally known that this undertaking, after passing through a great thickness of Chalk, met with a very insignificant representative of the sands which underlie the Chalk in the south-east of England, thence at once passed into strata which, by characteristic fossils, were identified as Palæozoic, and of Upper Devonian age. This was just as had been anticipated as to the absence of any portion of the Oolitic series there, and confirmed what many years since had been supposed to be the subterranean structure of the South of England; indeed, it might fairly be stated that geologists generally have been of opinion that a band of Palæozoic rocks extended from Westphalia westwards, and passed somewhere beneath the Secondary formation of the south-east of England. The importance of determining the course of such Palæozoic band was, that along the whole of the exposed part of its course, as from its extreme eastern place to near Valenciennes, it had dependent on it on the north the productive Coal-measures of Westphalia, Belgium, and the North of France. From Valenciennes westwards the Coal-measures were not exposed at the surface, but were reached beneath the Chalk formation, and from the underground workings the relations of the several members of the Palæozoic series were known to correspond exactly with those where the series were exposed, as was the case, also, where it was again seen at the surface in the Boulonnais, and at sundry other valleys of elevations along the axis of Artois. The whole of the Coal-measures of Belgium and North of France must be understood as occupying a trough formed out of the older members of the great Palæozoic series, and the explanation given of the preservation of this extended and narrow band of coal-growth surface was, that it had resulted from a contraction of the earth's crust in a south to north direction at some time subsequent to the completion of the Palæozoic series (Coal-measures included), whereby along the line a series of east and west undulations were produced, in the deepest or most considerable of which, portions of the coal-growth surfaces became included, so as to be preserved during the subsequent periods of denudation of the surface. From the consideration of the physical features of a line of country of elevation, and disturbance, which crossed the European Continental area for 300 leagues, he had inferred that like results were due to like causes here. The line of the Palæozoic strata having been conjecturally carried along close by where it has just been met with; so it might reasonably be supposed that certain other phenomena, which, in like manner, had resulted from the same disturbances, should also correspond and serve for guidance. For the present it had not been ascertained in what direction the highly inclined Devonian strata at Tottenham Court Road were dipping —a most important point in the considerations involved.

It might safely be supposed that, from position, any Palæozoic rocks at such place must be trending east and west, and the occurrence might seem to be an isolated fact, but for other inferences which tended to give it importance. The 653 feet of Chalk strata were horizontal, or with only a very slight north dip. The Devonian strata gone through dipped uniformly at about an angle of 30 degrees. The section, therefore, corresponded exactly with those of the North of France. In Belgium and the North of France it was on the south side of the Palæozoic trough that the high inclines occurred, as it happened along the whole line from Liège to Toulon. On the north the beds were flatter, and spread out wider. From this it might be supposed that it was the north side of the trough which was hit upon by Messrs. Meux; and that it was a trough at this place followed necessarily from the circumstance that the beds so highly inclined were as low as the Devonian. Bearing in mind that the whole of this part of Europe they were now considering formed part of the area over which the Devonian or Lower Carboniferous series preceded, or was overlaid by the Upper or true Carboniferous formations, and that when they occurred the other followed everywhere, the fact of the inclination of the beds at Tottenham Court Road involved this—that the higher formations must soon follow the Mountain Limestone on the Devonian, and the Coal-measures on the Mountain Limestone. This reasoning applied equally, whether the Devonian strata at Tottenham Court Road might be dipping north or south; but thus much had been ascertained, that London just overlies the edge of a great Coal-field, and the probability was that the Coal-field was to the north. What seemed to suggest that the Coal in this direction might have considerable extension was derived partly from a study of the geological features of their own island, and partly from what was the case in Belgium. It was dependent on what was the original form and extent of the coal-growth surface, and in the places at which the greatest amounts of contraction and subsequent denudation of the surface took place.

CORRESPONDENCE.

THE CORAL RAG OF UPWARE.

SIR,—In Messrs. Blake and Hudleston's admirable paper on the Corallian Rocks in England, "the well-known though very inaccessible exposure of Corallian beds at Upware" does not appear to have received from the authors such careful study as those in other localities. They state that in the northern quarry the beds "dip to the south, or in an opposite direction to those of the Rag-pit, so that there is a synclinal in which are found the Neocomian sands," and they give a "presumed section," in which the said sands are represented as so situated. Now this section is not confirmed by any evidence known to me. The dip in the northern pit—so far as there is any dip at all—is northward, not southward, probably a little west of north. I verified this a few days since in the company of three friends, all fairly accustomed to geological observation. Further, any one who has watched the working of the 'coprolite' pits, knows that the Neocomian beds rest unconformably on the Coral Rag, and thin out against the side of the ridge. The road along its crest (if one may use the word), between the two pits, nowhere crosses Neocomian beds. Two small shallow pits have indeed been opened adjoining the road on the west side, a little less than a quarter and half a mile respectively south of the northern pit. These seemed to be still in the same rock as it; and thus in all respects are unfavourable to the theory of a synclinal. The position of the strata was given some years since by Mr. Keeping in this Magazine (Vol. V. p. 272), and I have since examined several sections confirming this one, with the exception that I have never myself seen the Kimmeridge Clay exposed. Again, at the present time there is a considerable patch of the base of the Gault laid bare, just west of the south end of the Rag-pit, and perhaps four yards below the crest of the limestone; that is, exactly where it should *not* be on any theory of a synclinal. The stratigraphy is puzzling enough; but, so far as the evidence goes, it appears to me rather in favour of the old theory of an *anticlinal* as represented by Fitton (Trans. Geol. Soc., vol. iv. pl. xi.). The present authors may be right in assigning to the rock of the northern pit a lower horizon than that of the southern; but I have no hesitation in saying that the evidence at present is only palæontological, and this is not strong.

The other matter is a personal one, and refers to their mention of my own account of this district. I am well aware that in my Geology of Cambridgeshire it was "partially, but not very fully, described," because the book only professes to be a sketch for the use of students. At the same time, when authors call attention to an imperfection, one may fairly expect that they will considerably augment our stock of knowledge. I venture to assert that the questionable statement discussed above is the only material addition contained in the paper on the Corallian rocks. The two accounts are about equal in length, and contain as nearly as possible the same facts. Again, the authors' statement about the position which I assign to the Upware rock is, I think, so worded as to convey a wrong impression. "He correlates it with the lowest portion of the Corallian region, on account of its containing *Cidaris florigemma*, a reason which would make *us* assign to it nearly the highest." This, coupled with the rest of the paragraph, and their use of the word Corallian, would give rise, I think, to the supposition that I had placed the Upware rock below the Coral Rag. On the contrary, I take some pains to prove it to be Coral Rag, and the only support for this statement is that, as I was contending against Mr. Seeley's attempt to place the bed in the Kimmeridge series, and as *C. florigemma* was then supposed to characterize rather the lower part of the Coral Rag, I point out that the affinities of the Upware rock are downward rather than upward, so that it cannot even be paralleled with the Continental Séquanien. It is true that, according to Messrs. Blake and Hudleston, the position of the zone of *C. florigemma* is less constant than it was supposed to be; but in reasoning on that point, I used the best information to be obtained at the time, and the change does not materially weaken my main position that the Upware limestone is true Coral Rag, as the word was then understood.

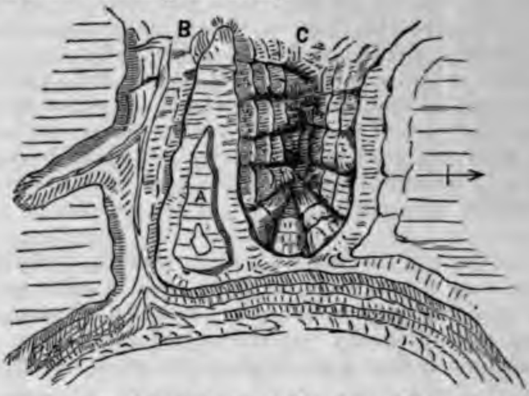
ST. JOHN'S COLLEGE, CAMBRIDGE. T. G. BONNEY.

THE ORIGIN OF CIRQUES.

SIR,—In a recent number of the GEOLOGICAL MAGAZINE (p. 273), Mr. Bonney has replied to the arguments adduced by Mr. Helland in favour of the glacial origin of cirques (Quart. Journ. Geol. Soc., vol. xxxiii. p. 142), and has adduced many cogent reasons in support of the explanation he has previously given, viz. "that the cirques are mainly produced by the combined erosive action of streamlets."

May I be allowed to cite what I conceive to be an illustrative case, occurring in a country which I have lately visited, and where it would be difficult to discover any traces of ice action, but where the erosive power of torrential rains is markedly exhibited? I refer to Upper Egypt, and especially to that district lying between the valley of the Nile and the Red Sea.

The eastern bank of the Nile above Cairo is bordered by a desert plain, about three or four miles wide, and stretching up to the high cliffs beyond, which rise into mountains some 600 or 700 feet high, and form the range known as the Arabian chain. These cliffs are furrowed by numerous deep gorges and valleys opening on to the desert plain below, over which is spread out the detritus brought down from the hills; for Egypt is not the rainless country it is sometimes represented to be, and in winter-time rain falls occasionally in quantity sufficient to convert these dry valleys into rushing torrents; thus among the recesses of the bare and barren limestone rocks, into which the valleys lead, signs of water-action are everywhere visible. A cirque in such a land as this could hardly be formed by any other agency than that to which Mr. Bonney attributes them, and yet a very cirque-like hollow came under my notice while exploring one of these ravines. I had ridden some distance along this, and, wishing to gain a better view of the country, I dismounted and ascended the steep slope which formed its northern side; I then found myself on a flat-topped ridge looking down into three valleys at once (as shown in diagram at A).



The watercourse I had been following (B) was cut off by a wider and deeper valley, here making a magnificent curve; and on my left was a deep, broad, and short hollow (C), only separated from the same valley by a narrow ridge or knife-edge. Its sides presented a succession of irregular steps, resulting from the weathering of the hard and soft beds of the limestone; but these were interrupted by numerous small channels and gulleys, and the heaps of *débris* which choked up the bottom testified clearly to the mode of its formation. Although evidently a rain-gorge, its cirque-like form struck me at first sight, and the reason of its taking this shape was easily perceived; having been cut backwards till a mere knife-edge remained between it and the valley beyond, elongate extension had become impossible, but the runlets which drained the flat-topped heights on each side had so extended it laterally that its width was already more than half its length.

Now is not this very suggestive of the origin of other cirques? Mr. Helland finds a difficulty in the fact that the part of the crest surrounding the cirque, and sloping to it, is so narrow that it cannot feed even a small stream. Mr. Bonney has shown that he should have said, "can only feed very small streams," and with this correction the sentence would fairly indicate the very conditions which I conceive to be essential to the formation of a cirque, viz. the concentration of small streams falling off a narrow mountain crest.

Mr. Helland himself says (p. 165): "The cirques which occur isolated in the mountains are not essentially different from the valleys which end in a cirque. . . . . They both occur in the same way, except that the valleys are longer, their area being as much as 25 times as great as that of the cirques." Surely he would not have us believe that these valleys are likewise the result of glacial action; and if not the valleys, then why the cirques?

In truth, as Mr. Bonney has pointed out, the cirque form is the natural termination of a valley cut back far into the hills; and I think it might almost be said that the farther a valley is carried back amongst hard rocks, the more cirque-like does its termination become; rounded hollows certainly do occur at the head of such valleys, and these might even become broadly subcircular, if the lateral streams happened to be stronger than the terminal.

Finally, are not cirques more rationally accounted for in this way, than by crediting glaciers with the curious "tooth-drawing" propensity which Mr. Helland suggests, and thus investing them with even more wonderful powers than have yet been claimed for them by the most devoted glacialists? A. J. Jukes Browne.

H.M. Geological Survey, Spilsby.

FOREST-BED AT HAPPISBURGH.

Sir,—I am glad to see that a discussion has arisen in your pages, which may lead to a more strict inquiry into the age and position of the portion of a submerged forest at Happisburgh, or Hasbro. If I recollect rightly, upon my first visit to Norfolk, Mr. Gunn took me to the spot, and told me that the Forest-bed (meaning the preglacial one) was usually to be seen open here, but only occasionally so at other places on the coast. I at that time collected some fir-cones from it.

At a subsequent visit I thought that the Boulder-clay passed under it, although I could not perceive what the actual superposition was. For I could trace the Boulder-clay to the edge of the foreshore, very close up to the Forest-bed; and there was no indication of those "laminated beds" of sand and gravel, which intervene between the Cromer Forest-bed and the glacial series. I therefore concluded that the deposit at Happisburgh was not a continuation of the Cromer bed.

Mr. Gunn, in a paper, which he read at Norwich in the spring of 1868, remarked upon this bed, and seemed to think it was not exactly coeval with the Cromer bed, but belonged to an upper portion of it, "which remained dry land on the partial submersion of the subsiding forest." He likewise referred to the absence of the "laminated beds." He also stated that "metatarsal bones of sheep or the goat were discovered here by Mr. William Haughton. The elephants had at that period died off from the increasing cold." Now the goat is not included in the list of mammals belonging to the Cromer bed as given by Prof. Dawkins at p. 417 of the Quart. Journ. Geol. Soc.; nor I believe is it usually known to occur in the *earlier* Quaternary formations. If then the determination of that genus be correct, it is rather an argument on palæontological grounds for a later date for the Happisburgh deposit.

It is of some importance that its true age should be settled, because the vegetable remains from it have been much relied upon as indicating the climate of the Cromer forest period, which possibly may after all be different. Cannot the true relations of the "hard" clay in which the trees are rooted be determined by digging a pit of sufficient size, so as to find out on what the Forest-bed really rests?

It may be in your remembrance that I threw doubts upon the preglacial age of this deposit in the paper which I read at the meeting of the British Association at Norwich in 1868.[1]

HARLTON, CAMBRIDGE. O. FISHER.

OBITUARY.

EDWARD WOOD, J.P., F.G.S.

BORN MAY 24, 1808. DIED AUGUST 16, 1877.

WE regret to record the death of Mr. Edward Wood, of Richmond, Yorkshire, President of the Mechanics' Institute, and of the Richmond Naturalists' Field-club, of which he was also the founder.

For more than thirty years Mr. Wood devoted his best efforts to the promotion of Natural Science, especially Geology, and he expended considerable sums of money and much personal labour in forming what is allowed to be the finest private collection of Mountain Limestone fossils in England. Many of the Brachiopoda have afforded the types for Mr. Thomas Davidson's splendid Monograph in the Palæontographical Society's publications. Prof. L. de Koninck, of Liège, has also figured many of his fine Carboniferous Crinoids, the best of which, perhaps, has been named after its discoverer *Woodocrinus*. To Mr. Wood's liberality is due the foundation of a Museum of Natural History in Richmond. For many years he undertook the pleasant and instructive task, at his own charge, of taking large parties of his fellow-townsmen to all the prominent geological localities within fifty miles. In promoting education among the young, Mr. Wood was always very active. In 1862, he took 100 poor boys from Richmond to London, and at his own expense conducted them daily to the Exhibition and elsewhere.

Mr. Wood was always most earnest and sincere in advocating the cause of Science; for many years he endeavoured, by the introduction of Science-lectures in his native town, to raise up a taste for intellectual pursuits among his fellow-townsmen. His loss will be greatly felt by a large circle of friends to whom he was endeared, not so much perhaps on account of his scientific attainments, as for his social worth and the kindliness of his disposition to all, even the humblest of his fellows.

COLOURING OF OOLITIC ROCKS.—Mr. Judd has pointed out that when dug at great depths or otherwise obtained at points where they have not been exposed to atmospheric influences, all the Oolitic rocks exhibit an almost uniform deep-blue tint, which is apparently communicated to them by a diffusion through their substance of small quantities of sulphide of iron.—H. B. Woodward, *Geology of England and Wales*, p. 188.

ERRATUM.—In Mr. J. R. Dakyns's article, August number, p. 349, line 4, *insert* "seen" *before* "above."

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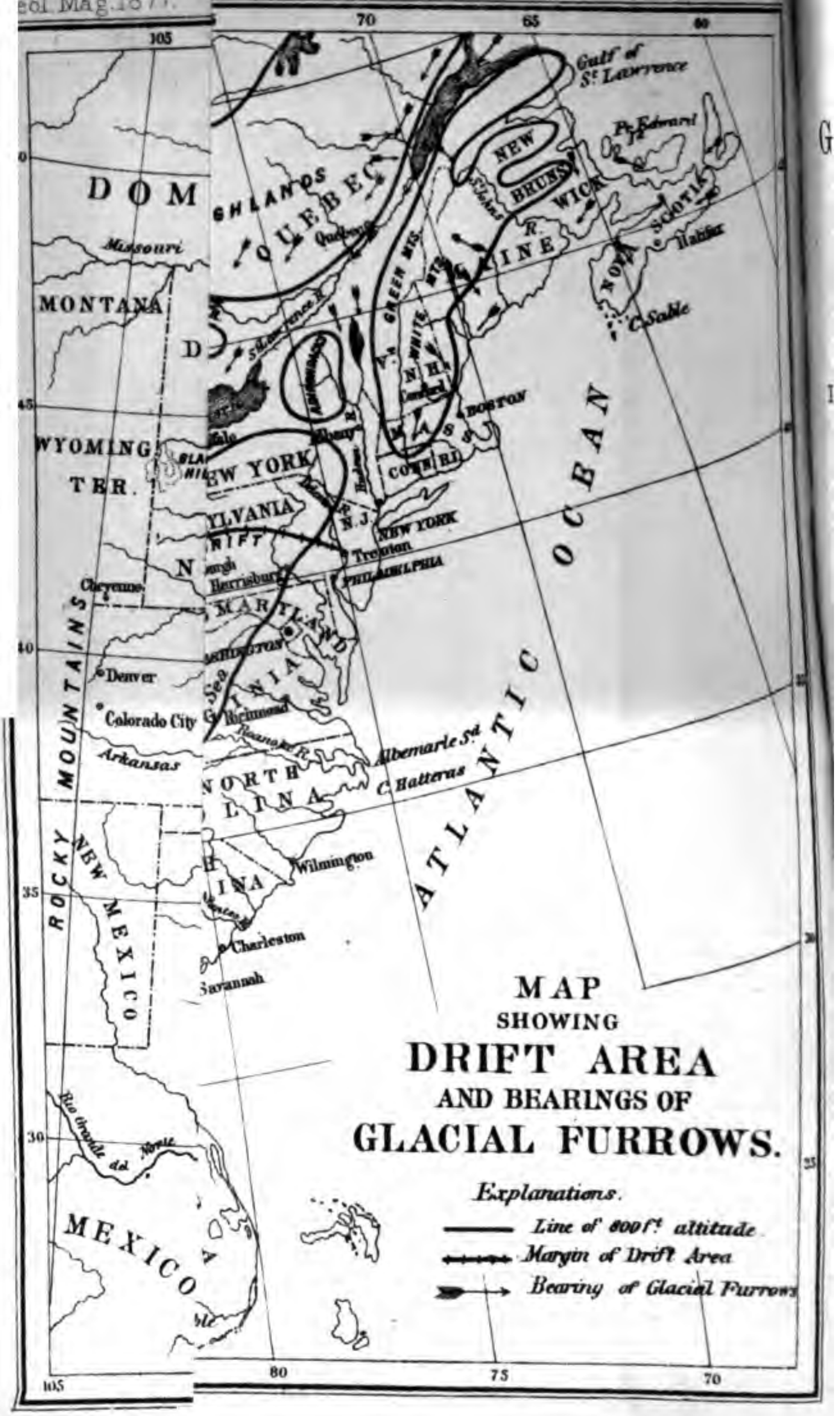
[1] See GEOL. MAG. Vol. V. p. 544, and Brit. Assoc. Rep. Norwich, 1868.



MAP
SHOWING
DRIFT AREA
AND BEARINGS OF
GLACIAL FURROWS.

Explanations.

—— *Line of 800 ft. altitude*
+++ *Margin of Drift Area*
➞ *Bearing of Glacial Furrows*

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. IV.

No. XI.—NOVEMBER, 1877.

ORIGINAL ARTICLES.

.—American "Surface Geology," and its Relation to British. With some Remarks on the Glacial Conditions in Britain, especially in Reference to the "Great Ice Age" of Mr. James Geikie.

(PART I.)

By Searles V. Wood, Jun., F.G.S.,

Illustrated by Two Maps and several Sections.[1]

(PLATE XV.)

FROM no part of the world have we of late years derived more additions to the Geological Record than from North America. Besides important additions to the earliest pages of that record, the rich collections made by the United States Surveyors, both of fauna and flora, from the Cretaceous, Eocene, and Miocene deposits, have thrown much light upon the life history of the Earth; and it is even contended that they have bridged over the interval which, notwithstanding the Maestricht beds, the Pisolitic, and the Faxoe Limestones, still remains sharply marked between the Cretaceous and Tertiary formations of Europe so far as they have yet been examined.

As regards those latest deposits, which, by adoption from the Frenchmen, as other fashions are from the Frenchwomen, it has become the fashion to call "Quaternary,"[2] and which have received of late years so large a share of attention from geologists, Americans have not been behind their European brethren in devoting to it abundant investigation. Memoirs and notices by Principal Dawson and others relative to the newer Geology of Canada have made us familiar with the general features of the Glacial and post-Glacial formations of the lower basin of the St. Lawrence, as have those of Professors Dana, Winchell, and others, with similar features in the United States, while recently[3] there has appeared, in the Report of the Geological Survey of Ohio, a comprehensive memoir by Prof.

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[1] The map of Yorkshire with sections will appear with Part III.

[2] Considering that the term "Primary" had long become obsolete, and that the term "Secondary" was fast becoming so, we might have been spared the absurdity of "Quaternary." However, as Crinoline has done so, I suppose, it will go out of fashion in time. The separation of Geology into "solid" and "superficial" officially made by the late Director of the Geological Survey of England, and on the basis of which the maps of the National Survey are to be delineated, is, to my mind, also an absurdity; but in deference to the leaders of fashion, I have adopted the term of "Surface Geology" in the title of this paper.

[3] The Surface Geology of Ohio, by J. S. Newberry (Columbus, 1874).

J. S. Newberry, on the "Surface Deposits" of that State, and their connexion with the general features of Glacial and post-Glacial geology presented by the Central and Eastern parts of the North American Continent; and from which the map of those regions that accompanies this paper is taken. A discussion of the views of American geologists occurs in the 35th chapter of the 2nd edition of Mr. Geikie's "Great Ice Age," and it seems to me that, in the present condition of our knowledge, the leading facts of this Memoir of Prof. Newberry may be usefully epitomized, and examined, in the way of analogy with those observed concerning our English Glacial and post-Glacial formations; and I propose here to make the attempt to do so.

Commencing with the oldest Glacial evidences in North America, Prof. Newberry describes the grooved and furrowed rock-surface, which is to be traced as far south as the 39th parallel of north latitude, and the extent and direction of which are indicated by the arrows on the map. This evidence of the occupation of the Eastern side of North America by glacier-ice is not confined to the basin of the St. Lawrence, but extends in the State of Ohio over the water-parting of the two great basins which receive the drainage of the central part of North America east of the Rocky Mountains; that is to say, it extends on to the northern edge of the basin of the Mississippi. These scratchings and groovings, though having a general north and south direction, nevertheless conform, according to Prof. Newberry, in a rude way to the present topography, and follow the directions of the great line of drainage. To the action of this ice when the continent stood several hundred feet higher than now, Prof. Newberry attributes the excavation of the basins of the great lakes, as will be further on described.

1. The oldest of the surface deposits is the Erie clay (No. 1), the origin of which Prof. Newberry attributes to the action of this sheet of glacier-ice during the period of its retirement before returning warmth, after the continent had become depressed 500 feet or more below its present level, and when the basin of the great lakes became, as this ice receded, occupied by an inland sea of freshwater.

He does not explain how, if the continent were depressed 500 feet below its present level, this basin could be occupied by freshwater, seeing that such a depression would bring all but the upper edges of the basin below the sea-level; nearly all the area of the basin of the St. Lawrence, as well as a large part of that of the Mississippi, inclusive of the water-parting of the two basins, being, according to the map which accompanies the Professor's Memoir and is reproduced here, below the 800-feet line. I presume, however, that he considers the sea to have been dammed out by a mass of the glacier-ice left remaining and filling the lower and narrow part of the St. Lawrence Valley, which lies several degrees of latitude further north than Ohio; but if so, there must have been an equal re-elevation of the continent before the growth of the forest surface (bed No. 2) over the Erie clay, because the warmth necessary for that growth must have thawed the dam and let in the sea, an event of which there seems no evidence, the only fossil organisms which occur in the deposits of the lake-basin being those of land or fresh-water. So far as I can understand the case, however, there seems to me no necessity to infer any depression until after the formation of beds Nos. 1 and 2, as the phenomena indicated by these beds seem explicable by returning warmth alone, and by the draining off of the lake-waters after the deposit of No. 1; while the marine clays of the Lower St. Lawrence, which, so far as I have been able to gather the facts of American geology, alone afford evidence of any submergence of the St. Lawrence basin, seem to me, as subsequently explained, to belong to a later glaciation.

Prof. Newberry contends that the lower and unstratified portion of the Erie clay represents the material eroded by the glacier, which, as the ice-sheet retreated northward, it thrust out and left behind; and which now forms a nearly continuous sheet of Boulder-clay over the glaciated surface. He urges that this clay was not deposited beneath the glacier-ice, because it covers the glaciated surface in a sheet sometimes 100 feet thick, and that it must have accumulated at the margin of the glacier as it receded. This, if we substitute the sea in Britain for the lake in Ohio, is in chief measure, the mode of origin for which I have for many years past been contending in the case of the Glacial clay of England, as distinguished from Mr. James Geikie's view of its origin beneath the ice itself.

There is one feature, however, connected, according to my view, with the origin of the unstratified Glacial clay of England to which I find no parallel in Prof. Newberry's memoir, viz. the lifting of portions of this extruded mass, and its distribution over the bottom, partly from being dropped in small quantities, but principally in sheets or masses. This seems to me to have been clearly the mode of accumulation in the case of that part of the English clay which overlies the Middle Glacial sands, as well as of some portion of that part of the clay which has no Middle Glacial beneath it, but which, as at Dimlington and Bridlington in Yorkshire, contains within its mass beds of sand full of lamellibranchiate mollusca with valves in some cases united. When, however, the vast area of the American beds comes to be examined with the same minuteness as has been the case with the comparatively small area of the British, I do not doubt that parallel features will be found in them, unless the water under which the moraine was extruded was too deep to allow of this process.[1]

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[1] If, as some American geologists say, unstratified morainic clay has been found overlying the forest surface *in sitû*, then these would seem to me to be instances of dropping from floating ice; for if the ice passed over the forest, it must have destroyed it. Some of our Norfolk geologists are now coming to the opinion that the long-known Forest-bed of Cromer is not *in sitû*, but transported; and if they are right, the theories based upon the occurrence of peats and freshwater shells in the midst of Glacial clay will require much reconsideration. This, however, does not apply to the Pakefield and Kessingland root-indented bed, which is clearly *in sitû*. If it should turn out that the Cromer Forest and freshwater deposits associated with it are not *in sitû*, but stripped from some distant land-surface by ice, and transported, analogy for such a thing may be found in some peaty masses which I have observed imbedded in the midst of the marine-formed Contorted Drift in the Cromer cliff itself.

Mr. Geikie insists on the purely terrestrial origin of all this unstratified Glacial clay, and urges his views in the "Great Ice Age" with the amplitude for which a work specially devoted to the Glacial formation affords scope. It is impossible to meet his various contentions within the limits of a paper like this; but to insist, as he does, that rock-basins and great valleys of erosion have been excavated by the tremendous agency which is exerted by the combined vertical and horizontal force of glacier-ice thousands of feet thick moving over its bed, and at the same time to contend that this ice can have passed over finely-stratified sands, such as the Middle Glacial, pushing at the same time under it a thick moraine of clay brought from a distance, without disturbing the stratification in the slightest, does appear to me a most striking inconsistency. We are reminded by it of the steam-hammer which forges a 100-ton gun and cracks a nut without crushing the kernel; but glacier-ice is not kept under the delicate control that a steam-hammer is. Not only is the stratification undisturbed, but within very few feet of the junction of this undisturbed stratified sand with the morainic clay there occurs in several places, both in the East Suffolk cliff and in sections inland, a band of molluscan remains, mostly fragmentary, but containing intermixed with them an abundance of small papyraceous specimens of *Anomia ephippium*, and of the valves of *Balanus*, sharp and unworn, both of which have evidently fallen from objects floating in the sea. These small *Anomiæ* are so thin and tender that in the fossil state in which we find them they exfoliate, and may be blown into fragments by a strong breath; and in their living state they must have been very fragile. Are we to suppose that glacier-ice hundreds, nay, according to the extreme glacialists, thousands[1] of feet thick passed over these sands, rolling its moraine as it progressed, without either distorting the stratification of such sands or crushing the tender organisms within them which lie but very few feet from the line of junction?

This inconsistency becomes to my mind enhanced by Mr. Geikie's contention that the worn shells and shell fragments which occur in some of the morainic clays, as, for instance, in the purple clay of Holderness, the chalkless clay to the north of it, and in the Lancashire clays, are due to the ploughing out of anterior (inter-Glacial) sea-beds, and the intermingling of the ploughed-out shelly matter with the land-derived moraine material; for how, if such things occurred, could the sea-bed formed of the Middle Glacial sands to which I have referred have escaped destruction if the glacier assed over it? The shells and shell-fragments, more or less worn, vhich occur in these morainic clays, owe their presence in my opinion o the alternate advance and recession (such as now in Greenland ccurs from century to century) of the glacier-ice along the subnarine valleys or fiörds, through which its escape to the sea took lace; by means of which the sea-bottom of these fiörds was loughed out and became mixed up with the moraine on the dvance of the ice, and, thus intermixed, was deposited where it is.

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[1] In objecting in my paper, "On the Climate Controversy," in this Magazine for September, 1876, to the extreme thickness assigned to the ice of Britain during the Glacial period, I spoke of the existing Antarctic ice being at least 5000 feet thick. In this I was led away by the instances of bergs of tabular form having been met with in Southern seas which rose more than 500 feet or 600 feet above the sea, given by Dr. Croll in his work on "Climate and Time." From the description of the Southern bergs, however, given by the *Challenger* Expedition, I do not see how the Antarctic ice can at its sea termination much exceed 2000 feet, even if it reaches that. It seems probable, however, so far as Greenland and Spitzbergen disclose the case, that land-ice is of less thickness at the glacier terminations than where it lies in greater masses further inland.

To the same action, I conceive, was due all that part of the shelled contained in the upper layers of the Middle Glacial sands just eferred to which consists of worn shells and shell-fragments; these aving been carried away by the currents when the ice advanced on he submarine valleys, and been deposited in these sands in assoiation with organisms fallen from floating objects. When the lacier-ice receded, this ploughing-out ceased, and the moraine acordingly ceased to be intermixed with shell-fragments, portions f it being carried away and dropped over these sands, while he bulk of it remained as extruded during recession on the bottom pon which the glacier had rested.

Different, however, to this must have been the conditions to which he sand thread full of perfect valves of *Nucula Cobboldiæ* which is resent in the midst of the morainic clay near the foot of Dimlington liff owed its origin; for in that case the only explanation seems to e that the shells established themselves in a thin bed of sand eposited on the submarine moraine, and were afterwards killed nd buried by the descent upon them of a sheet of the moraine ifted from some other place. This bed or thread of sand with hells was discovered by Prof. Hughes and Mr. Leonard Lyell, uring a visit made by them to the Holderness coast, in company vith Sir Charles Lyell; and in a memorandum sent to me with he shells by Sir Charles, the thread of sand was described as ntercalated in the mass of the unstratified chalky clay, *and packed vith perfect valves of Nucula Cobboldiæ and other shells,* some of hem having the valves united. The position of this thread appears o have been below, but near to, the beds of sand occupying hollows n the chalky clay forming the lower part of Dimlington Cliff, nd which were distinguished by Mr. Rome and myself in our secions[1] by the letter *b*, and which are overlain by the purple clay, lso full of chalk debris in its lower part, but getting less and less pwards till such debris disappears altogether from the clay. These and beds, *b*, are very irregular, and in some places they are internixed with, and in others replaced by sheets of morainic clay, vhich present the distinct appearance of having been dropped uccessively. Mr. Geikie, in referring to the beds thus described y Mr. Rome and myself under the letter *b*, speaks as though ve regarded them as marking an interval in which the chalky clay was converted into land and denuded, and then subsequently depressed beneath the sea; but this view was only offered by us as an hypothesis alternative to that which we regarded, and which I still regard, as the true one, viz. a change in the source of the morainic material due to the recession of the ice from the chalk country, which the gradual diminution upwards in the overlying clay of the chalk debris, and its eventual disappearance in the uppermost portion, seemed to us to indicate. In many subsequent references that I have made to the purple clay of Yorkshire, I have invariably regarded it as one continuous deposit with the chalky clay of East Anglia, and with the chalky clay which, underlying the purple, forms the base of the Glacial formation of South-Eastern Holderness, and seems identical with that of East Anglia. So far from being a separate deposit, this purple clay with lessening chalk debris, forms, in my view, about the middle portion of that one unbroken formation, the Upper Glacial, the deposit of which took place mainly in the horizontal form, and of which the chalky clay of East Anglia, and that forming the basement clay of South-East Holderness, constitutes the earliest and preceding part, and the chalkless clay of Holderness, into which the purple clay with chalk passes up, and the clay of the more northern counties, constitutes the succeeding parts.

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[1] Quart. Journ. Geol. Soc. vol. xxiv. p. 148; and Palæontographical Society's olume for 1871; Introduction to Crag Mollusca, Supplement, p. xxv. They are lso shown in the section which accompanies the sequel of the present paper nder the letter *b*.

Reverting to the case of morainic clay resting upon stratified sands with marine shells, I would call attention to the evidences which are available to show what kind of effect has actually resulted from the action of glacier-ice upon strata softer than rock when these formed the floor occupied by it. Thus in Norfolk we have evidence of glaciers having occupied the valleys which were cut out which, where it did not sweep them out altogether, twisted them up in a violent manner with other sands on which they had reposed.

Can any one contend in the face of this that sands would be left undisturbed by glacier-ice moving over them with vast pressure?

In describing the morainic chalky clay, of which the Upper Glacial in East Anglia is formed, as having arisen in part from droppings, I have, until now, spoken of the dropping agent having been bergs, but it has since struck me that I have been to that extent in error. I was led to this view because, while it seemed to me clear that the morainic matter was dropped from floating ice, I was pressed by the impossibility of floe (or sea surface-formed) ice attaching itself to morainic material extruded in deep water.

In the case of this chalky clay, however, though the evidences of its having arisen in part by the droppings of the material from floating-ice are to my mind conclusive, yet we fail to find evidences in it of the action of grounding bergs, such as is so conspicuous in the case of the Contorted Drift. At the same time the general bearing of the facts connected with the accumulation of the chalky clay seems to me to indicate that during it the sea in East Anglia was too shallow to give rise to bergs, for these only break off where the water is deep enough to buoy up and break off the glacier termination. It is only some of the Greenland fiörds where the water is very deep that thus give rise to bergs, for in others the glacier ending in shallow water melts in the sea, and fills up the fiörd with its moraine.[1]

We must, I now think, infer that the agent by which this dropping was accomplished was floe ice packed in winter around the glacier's termination which froze to the bank of morainic material at the glacier's foot, and so carried it away in sheets and masses during summer.

Resuming now our examination and enumeration of American Glacial phenomena, we find that the Erie clay, which in its lower part is unstratified like the Upper Glacial clay of East Anglia and of the North of England, and the Scottish Till, is similarly *full of rolled debris*; and it is described by Prof. Newberry as passing up in Ohio into laminated beds which he attributes to the deposit of the finer material ground up by the glacier-ice and suspended in the water of the basin. The interbedding of material ground up by glacier-ice in ordinary mud in the form of streaks of chalky silt, may be distinctly seen in the Contorted Drift of Cromer Cliff, as we follow it north-west from Cromer towards Weybourne, that is to say, towards the place where, during the formation of this Drift, the glacier discharged into the sea. In the chalky clay (or Upper Glacial) of East Anglia, owing, as it seems to me, to the shallowness to which at that stage of the Glacial period the sea had in that part of England become reduced, we do not encounter this feature;

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[1] Brown, Journal of the Geographical Soc. for 1871, p. 351. Mr. J. W. Tayler, also, in the same journal for 1870, p. 228, says that numerous fiörds in Greenland have been so filled up by the moraines extruded by the glaciers, that boats hardly find depth of water enough to ascend them, while one of the glaciers, that north of Fredrickshaab, which is 15 miles wide, and ends, not in a fiörd, but on the open coast, has formed a beach at its base with the moraine it extrudes.

but in Holderness, where the chalky clay passes up into the purple, and where, as explained in the sequel, the water was deeper, though not deep enough to form bergs, the morainic chalky clay does seem to pass up, through an intermediate stage formed by dropped sheets of morainic matter, into clay of the character which Prof. Newberry describes the upper portion of the Erie clay to be; for though it is not usually laminated, it is full of lenticular beds of sand, and to my eye presents the appearance of a clay formed by marine deposit from the ground-up material of a glacier carried away in suspension, and accompanied by copious droppings of rock debris from floating ice (see the clays *c* and *d*, with lenticular beds of sand and gravel, *c′* and *d′* therein, shown in the sheet of sections accompanying the sequel of this paper).

On the Canadian highlands, where the material acted on was harder, and where free drainage, as he calls it, washed away the finer portions, this clay, Prof. Newberry says, is largely replaced by gravel-sands and boulders. As the gravel-sands of these highlands could not, however, have been accumulated until the glacier-ice had receded from thence so as to give place for their deposit, we seem to have here a formation of Eskers and Kames, such as is discussed further on. If the gravels of these Canadian highlands occupy, as I imagine they do, elevations above the Erie clay, and also above that to which the submergence under which the Leda and Champlain clays accumulated reached, it seems to me that they must be Eskers or Kames formed by the melting of the glacier-ice when it ceased to discharge its moraine beneath the Atlantic, and beneath the lake waters, and had receded to these highlands. If, however, they be not thus referable to Kame and Esker origin, or if they contain marine organisms, they would, perhaps, answer to the Mountain (Moel Tryfaen) and high-level (Macclesfield) sands of England and Wales, which represent the latest portion of the Upper Glacial formation when the ice-sheet had wasted back to the mountain peaks, and North-west Britain had assumed the condition of an archipelago. Assuming them, however, not to be of marine origin, but Kames and Eskers (which, as presently explained, is the form assumed by the moraine when the recession of the ice takes place subaërially), it seems to me that they must be the product, and the latest product too, of the last glaciation to which the region they occupy has been subjected; for not only would the ice in its subaërial recession leave such beds, but it must, it seems to me, have ploughed out and destroyed the formations of any previous glaciation wherever it encountered them in its advance, and therefore up to wherever such subsequent ice reached.

Prof. Newberry observes that although the Erie clay occupies the same relation to the glaciated rock-surface as do the "Leda," "Champlain," and "Glacial" clays of the Atlantic coast, there is not sufficient evidence to connect them as exactly synchronous; but he considers that these Atlantic coast clays were formed in a similar way to that of the Erie clay; that is to say, during a subsidence of the Eastern coast of North America when the Atlantic waters in following the retreating glacier covered, and in part stratified, the material ground up by it. In this view he (as do also several American geologists) differs from Principal Dawson, who has attributed the glaciation of the Atlantic coast to an Arctic current carrying icebergs, instead of to glacier-ice, either solely or in connexion with a following sea. It seems to me, however, as explained presently, that though formed in the way Prof. Newberry contends, they are more probably synchronous with the beds 3*a*, presently described, or even to some extent with the Lake terraces, or beds No. 4.

2. The formation which immediately succeeds the Erie clay in Ohio is, according to Prof. Newberry, that of a terrestrial surface indicated by forest-beds with logs and stumps, and sometimes upright trees, of which beds he gives many instances. This formation (No. 2), or the deposits associated with it, contains the bones of Elephant, Mastodon, and the giant Beaver, and it indicates, according to the Professor, a climate somewhat colder than that now prevailing in the same region, though some of the forest-remains of Ohio contain a large number of plants still growing there.

With reference to this terrestrial surface, Prof. Newberry observes that *no certain proof has yet been detected in America of the return of the glaciers to the area which they had before occupied and abandoned after the intervention of a milder climate, such as is found in Europe.* Now the preservation of so considerable an extent of forest-grown surface to the Erie clay, that is, between the deposits No. 1 and those presently to be described under the symbol 3*a*, seems repugnant to such an oscillation of climate; because this surface, and indeed the Erie clay itself, would, we must infer, have been ground out and destroyed by any re-occupation of its former site by glacier-ice,[1] and in such case the deposits which succeed it would all appear to belong to that period which, having followed the retreat of the confluent glacier-sheet in Britain and the elevation of this country from its general submergence, English geologists have hitherto been accustomed to call post-Glacial.

If, however, Prof. Newberry is right in regarding the glaciation which gave rise to the Erie clay as having taken place when Ohio stood 500 feet and more above its present level, and the beds which succeed the forest-surface as having been accumulated when the same area was depressed to as great or even greater depth below that level, this difference of altitude (1000 feet) may have so reduced the second glaciation as to prevent the re-occupation of the Erie clay area in Ohio by glacier-ice, notwithstanding the return over the earth

[1] This, as described further on in the present paper, has been the case with the Lower Glacial deposits in England. Mr. Geikie seems to see no difficulty in glacier-ice passing over forest-surfaces without destroying them, although to such ice is attributed the excavation of great valleys and rock-basins, but I do not believe in the possibility of such a thing, the two resulting actions appearing to me irreconcilable with each other. According to Prof. Dana the thickness of the ice which passed over the northern part of the United States was 6000 feet, exerting a pressure of 300,000 lbs. to the square inch, while it was double this on the watershed between Canada and Hudson's Bay. I am, however, very sceptical of these vast thicknesses of ice anywhere.

generally of conditions as frigid as those which prevailed during the first glaciation. On the other hand, if there never was anything more than such a limited depression of the St. Lawrence basin as sufficed to bring the Atlantic waters over those parts which are covered by the Leda, Champlain, and other marine clays of the coast districts (and I fail to see how there could have been more), we should not find this explanation of difference in level available as an explanation, but be driven to infer that the glaciation to which the beds overlying the forest-surface were due was a minor one; so that the ice did not reach to its former position, but damming up the lower valley of the St. Lawrence (which lies in several degrees higher latitude than Ohio), it filled the lake-basin with the waters produced by its dissolution, over which drifted the ice from whose droppings and from the mud and gravel taken up by currents from the glacier discharge, these beds appear by Prof. Newberry's description to be made up—beds which possess very much the physical character of the Contorted Drift of Cromer, without its included marl masses, as well as of the purple clay of the district near Flamborough Head which is shown in the sections accompanying the sequel of this paper under the letter *d*.

3. The beds thus overlying the forest-surface in Ohio consist, according to the Professor, of clays, sands, and gravels of various kinds, sometimes containing boulders as well as having boulders extensively scattered over them. These beds, to which I have already referred under the symbol 3*a*, he considers were deposited by the lake-waters while the Canadian highlands were occupied by glacier-ice, from which bergs breaking off drifted over the lake-basin and scattered blocks.

Looking at the general group of facts affecting the American region as described by Prof. Newberry, and at the general facts with which a long study of the English beds have made me familiar, I strongly incline to the belief that both in America and in Europe there have been two glaciations only; one, the greater, during which the beds that I term glacial were accumulated, and when Britain underwent its general submergence; and the other, the less, which was subsequent to the general emergence of this country, but occurred while the South of England was still partially submerged, and the North of England and South of Scotland had undergone partial resubmergence, and during which the older part of the beds that I term post-Glacial were accumulated. I think that if we take into consideration the greater height of the glacier generating land in Britain over that in Canada, this minor glaciation bears the same proportion to the major in both countries; for the Canadian highlands forming the northern lip of the St. Lawrence basin, and on which, according to Prof. Newberry, the ice terminated and sent off its bergs during the accumulation of the beds 3*a*, lie between latitude 45° and 50°, which is at least 5° of latitude short of that to which the grooved rock-surface of Ohio shows the glacier-ice giving rise to the Erie clay had reached. In Britain there is not this difference in latitude between the limits of the major and minor glaciations, and it seems to be still less in Switzerland, because both countries are more mountainous than Canada, and the conditions are therefore in this respect not parallel; but the similarity is to be discovered in the circumstance that the glaciers of the minor glaciation were in Britain nonconfluent (to any great degree at least), while in America the confluent sheet which they formed was arrested on the Canadian highlands instead of reaching to the centre of Ohio, as the confluent sheet of the major glaciation had done.

Inasmuch as during its greatest extension the ice in Britain did not reach much, if any, south of the 52nd parallel, while in Eastern North America it reached to the 39th, it seems clear that the marked difference in climate between the two regions which now exists, and is due to the influence of the Gulf Stream and the action of the prevalent winds, existed in a similar degree during the major glaciation; and we are assured by American geologists that in a similar way the existing preponderance of winter cold in Eastern North America over that in Western, which now obtains, obtained also during the Glacial period, as the evidences of glaciation have not on the Pacific coast been detected much if at all south of the 49th parallel. These appear to me to be very pregnant facts indicative equally of the cosmic origin of the Glacial period, and of the inapplicability of the Excentricity theory of Dr. Croll to its explanation; because, by the express statements of its author, the influence of excentricity would be inoperative on climate were it not for its effecting a complete diversion from Western Europe of the Gulf Stream, and its similar operation upon the great currents of the Pacific and other oceans, as well as the prevalent winds.

An identity of character between the vegetation which intervenes between the Erie clay surface and the beds *3a*, and that now growing in the same region, would, if free from question, be of great importance, because so much uncertainty attaches to the evidence afforded by mammalian remains upon the question of climate; some geologists contending that we are entitled to infer from the presence of certain of these mammalia, especially the Hippopotamus, a period of warm or at least temperate climate; while others insist that mammalia adapt themselves so easily to all climates that they furnish no reliable evidence upon the question; and they endeavour to get over the difficulty of the Hippopotamus inhabiting a country whose rivers would have been thickly frozen over during winter, under conditions of climate much short of glacial, by attributing to this animal migratory habits like those of the Reindeer and Musk Ox, notwithstanding that in its living state it, and indeed, I believe, all Pachydermata, show, as far as known, no migratory disposition at all. In the case of a flora, however, to a great extent identical with one still growing on the same region, no such uncertainty could, I think, arise; and if, therefore, in the interval between the Erie clay and the beds *3a* we got such a flora, we could hardly deny the intervention of a temperate climate; and were such an established fact in American geology, it would furnish a strong support to the case of a similar interlude between those two glaciations of major and minor extent, of which I consider the English formations to afford evidence. Prof. Newberry, however, observes that most of the forest intervening between the Erie clay and the beds 3*a* was Coniferous, and that as it includes the Cedar and Cranberry, it may be regarded as indicating a climate somewhat colder than the present; for it is not clear that the forest-beds which yield so many of the plants which still grow in the same localities, and which could not have grown if the climate had been much colder, are of the same age as are those found intervening between the Erie clay and the beds 3*a*.[1]

It should, however, be borne in mind that if the forest-beds thus intervening be *in situ*, a great amelioration must, it seems to me, have ensued; for unless the ice had completely thawed out of the lower valley of the St. Lawrence, which lies in several degrees higher latitude than Ohio, the lake-basin could not have been laid dry so as to support a forest growth; because an amelioration sufficient only to release the Ohio portion of the basin from the glacier-ice indicated by the Erie clay, and by the striated surface down to latitude 39°, would have only brought about those conditions which are described by Prof. Newberry as giving rise to the beds 3*a*, and which I have attributed to the return of a minor glaciation; viz. the filling of the Ohio lake-basin with freshwater instead of the formation of a land-surface. Moreover, how could the lake-basin have again become filled with freshwater after a land-surface, unless a return of glacial conditions took place, minor in degree, but sufficient to dam up the lower valley of the St. Lawrence with ice?

Whatever may prove to be the case, however, as to the nature of the terrestrial climate which preceded the minor glaciation, I think this water-parting, and so invaded the lake-basin, some marine organisms do not occur in the deposits of that basin. Not only does Prof. Newberry make no mention of any such, but Mr. Hinde, in a paper in the Canadian Journal for April, 1877, insists that none but land and freshwater organisms have occurred in them. It seems to me, therefore, in the absence of better explanation, that the gravels thus occupying the Ohio water-parting are not of marine origin, but have come into existence in a different way altogether, viz.:

Not having seen the Kames and Eskers of Ohio, or even those of Ireland, I of course can only form my opinion by analogy; but those of Scotland I have seen throughout most of the Highlands of that part of Britain, and on both sides of them as far north as Inverness; and it appears to me that Mr. Jamieson's view of their origin, from the melting subaërially of ice which formed in the mountain districts of Scotland posterior to the emergence of our island from its great depression, is the correct one. Not only so, but nothing to my mind is more confirmatory of the view for which Prof. Newberry and I contend of Glacial clay, or Till, having had a submarine origin, than the contrast afforded by this Esker and Kame drift. When a glacier terminates in the sea, or a lake, the moraine material extruded and left behind by it in its recession is only washed out into gravel where it is subjected to current action. This action is exceptional, and may perhaps be induced by the outflow here and there of streams of freshwater from beneath the ice. In whatever way, however, the currents be caused, the formation of gravel during morainic extrusion with submergence seems to me to be partial, and the great bulk of the material to be accumulated in the unwashed form, because nearly all the glacier-ice is either carried away piecemeal from the termination of the glacier in the form of bergs, *to dissolve elsewhere*, which is the case where the water is deep enough; or else it wastes imperceptibly away into the sea that washes the glacier, which is the case where the glacier terminates in water too shallow to give rise to bergs. When, however, the glacier ends short of the sea, *i.e.* on land, these conditions are reversed; for all this ice dissolves in the glacier itself, and pouring from beneath it as water forms a torrential river, washing out the moraine material into gravel, which the glacier as it recedes leaves in heaps and ridges, while the muddy particles are carried off in suspension by the river. Thus, it appears to me that the unfossiliferous gravel which forms the principal part of the Drift of the Scottish Highland valleys arose from the melting back subaërially of the nonconfluent glaciers of the Hessle period. This period I contend was one of limited re-submergence which, reaching its maximum during the deposit of the Hessle clay, was confined to the northern parts of Britain. It is also the period, as it seems to me, during which the Glenroy roads were formed; and I observed that near the sea or the great lochs in the southern extremity of the Highlands, the moraine material consisted principally of gritty Boulder-earth, and at the northern extremity, as about Inverness, it passed downwards into similar earth; while in the higher valleys of the Highlands the Drift was entirely of Kame character, i.e. gravel with boulders, though Boulder-earth covers the mountain sides up to great elevations. Assuming, therefore, that the north of Britain rose from its limited submergence during the Hessle period, and before the glaciers occupying the valleys of the mountain districts had wholly melted back, and then, after its elevation, that this melting back took place subaërially, we seem to me to get an explanation of much of the complex and seemingly conflicting phenomena of that region; for in the higher valleys which the limited post-Glacial submergence was insufficient to bring down to the sea-level, the valley drift would be all of this character, while in the lower valleys, especially towards their seaward terminations, the lower part of the Drift would be principally unwashed moraine, and the upper part of it washed Kame gravel.

Applying this now to the case of Ohio, and assuming, for the reasons given previously, that no depression of that part of the continent took place until after the growth of the forest-surface (2), which rests on the Erie clay, it appears to me that when the ice-sheet to which Prof. Newberry attributes the Erie clay reached to and rested on the water-parting between the St. Lawrence and Mississippi basins, where these Esker and Kame gravels are found, and where the grooved rock-surface attests the former presence of the glacier-sheet, its dissolution was all subaërial; and the water resulting from it escaped into the Mississippi valley, so that the resulting moraine was washed out into Kames and Eskers; but that so soon as it wasted back from the water-parting, and into the St. Lawrence basin, the melting of the ice began to form a lake, and this washing out of the moraine ceased. The moraine then extruded, being all left subaqueously, retained its original unwashed form of Glacial (Erie) clay, similar in character to the Upper Glacial clay of England, which was left beneath the sea by the retreat of the ice-sheet during the general submergence of Britain. If this view be sound, the age of the Ohio Kames and Eskers which, following the sequence assigned to them by Prof. Newberry, I have called *3b*, would really be that of the oldest portion of the Ohio Glacial series, viz. coeval with the Erie clay (No. 1), of which they would constitute in the horizontal sequence of Glacial deposits the earliest portion.[1]

The occupation of the Canadian highlands by an ice-sheet subsequently to the growth of the forest over the Erie clay seems to me to conspire with the evidence afforded by the recent character of the mollusca of the Leda, Champlain, and other marine clays of the lower basin of the St. Lawrence, and Atlantic coast, to show that these marine clays belong to a later glaciation than that to which the Erie clay owes its origin; because I cannot, as I have already observed, conceive that with such vast erosive power as is attributed to glacier-ice any deposits of prior Glacial age could survive its destructive agency, so far as it extended. In the case of the older Glacial beds of East Anglia they remain undestroyed, it seems to me, only so far as the subsequent ice giving rise to the Middle and Upper Glacial formation did not extend. The depth of the water under which the Lower Glacial of East Anglia accumulated renders it difficult to conceive that this formation did not extend north and west of the limits to which it is now restricted; and it must have extended either in a marine or terrestrial form as far northwards as the ice to which it owed its origin wasted back or deflected; so that when we combine the absence of any formation representing it in the North of England with the Crag-like character of the mollusca of its basement sands, it seems but reasonable to regard this earlier part of the Glacial series as having been largely destroyed by the subsequent advance upon it of the ice.[1] Now there is an absence from the marine clays of the Lower St. Lawrence basin, and of the Atlantic coast, of any species of mollusca but such as still occur in a living state either in the Atlantic or in the Arctic sea immediately north of it,[2] while there are Crag forms in the English older Glacial beds, which are not known as living at all; and others, which, if living, are only represented by species known as such in the North Pacific; and two of these, as, e.g. *Nucula Cobboldiæ*, and *Tellina obliqua*, range in our Upper Glacial clay up to what I regard as about the middle place in its horizontal accumulation, viz. Dimlington Cliff base, and Bridlington. This leads me to think that the marine clays of the Lower St. Lawrence and of the Atlantic coast were deposited during the time of the later or minor ice-sheet which gave rise to the beds 3*a* of Ohio. Mr. Geikie also in his second edition refers these clays to the later part of the Glacial period as defined by him, which corresponds with what I call post-Glacial.

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[1] Prof. Newberry observes that only patches of the Erie clay occur on the water-parting which is the region of these Kames, and in the details of sections that he gives, these Kame gravels do not rest on the Glacial deposits, but on the rock-surface. Mr. Geikie, in the second edition of his "Great Ice Age," similarly suggests that the Ohio Kames were due to the action of water flowing from the glacier-ice when it reached to the centre of Ohio, but he does not of course recognize such a distinction as I have endeavoured to draw between the deposit formed by the subaërial extrusion of the moraine and that formed by its subaqueous extrusion.

Besides the beds above described, and those yet to be mentioned under the number 4, there is the great Bluff formation or Loess of the Mississippi valley, described by Sir Charles Lyell in the successive editions of his well-known works, and in which at Natchez he mentions the occurrence of a human pelvis.

This formation Prof. Newberry regards as the silt brought down by the rivers which form the Mississippi drainage system when in flood, and spread out over the great valley as the sea by the elevation of the continent receded from it, the chief contributor being the Missouri with its affluents. There is, he says, evidence that the lower part of the valley near New Orleans was depressed nearly

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[1] The line up to which this formation, and also the Middle Glacial and earliest part of the Upper, have been destroyed by the subsequent ice is defined in a note to the sequel of this paper.

[2] This, at least, is my impression, from the works to which I have had access. If the facts are otherwise, then my argument to that extent fails.

1000 feet below the sea-level; and as this must have brought the sea very high up the valley, its recession was a long affair, and the mud of the Bluff formation consequently represents the long period of this recession which its outspread accompanied, the portions at higher elevations being the oldest. He adds that this submergence brought the waters of the Gulf of Mexico up the valley of the Mississippi until the sea covered all the lower half of Ohio; and that it was during the maximum of this submergence, and during the accumulation of the beds 3*a*, that the action of the shore-waves formed the Kames and Eskers which occur on the watershed between the two basins; but, as I have before observed, if the sea had thus overflowed the water-parting, we are met with the difficulty that the waters of the lake-basin would have become salt, of which no evidence is offered. Neither does Prof. Newberry offer us any evidence of marine organisms to prove the occupation of the upper parts of the Mississippi valley by the sea. He describes certain clays with sands and gravels, which, occurring in Southern Ohio, belong to the deposits of the Mississippi basin; and these, he says, overlie a forest growth, which seems to be a continuation of that which, lying within the St. Lawrence basin, occurs over the Erie clay, and appear to be identical in age with the beds 3*a*. The relation which these clays, etc., bear to the Bluff formation of the Mississippi, he does not point out with sufficient clearness to enable me to apprehend precisely his view about them, but so far as I can gather from his memoir (p. 37), he regards them as the equivalent of that formation. If, however, the depression about New Orleans was coeval with that to which the marine clays of the Lower St. Lawrence and of the Atlantic coast are due, the Bluff formation would seem to have begun before this. Looking at the subject in the whole light afforded by the examination of the Glacial features of the St. Lawrence basin, as described by Prof. Newberry, it seems to me that the Bluff formation of the Mississippi valley must represent both the Glacial and the post-Glacial periods, and have commenced as far back at least as the Erie clay. Indeed, if the suggestion that the Kames and Eskers of the water-parting between the two basins in Ohio originated from the subaërial dissolution of the ice of the first sheet, when it rested there before shrinking back into the St. Lawrence basin, and forming a lake, be sound, the finer mud carried off by the water in forming such Eskers and Kames must have found its way into the Mississippi valley, and contributed to the material of the earlier part of the Bluff formation, whatever submergence the Mississippi valley underwent having been confined to its lower or Gulf extremity.[1]

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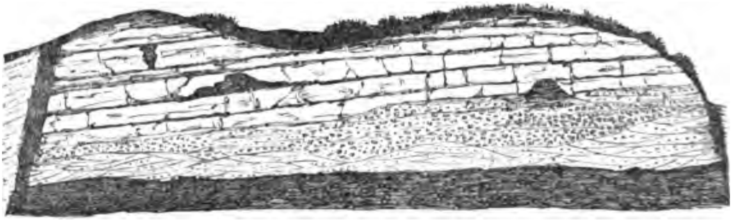
[1] In reference to this suggestion it would be interesting to learn to what extent rock-fragments have been found in the Mississippi valley which can be identified with rocks *in situ* in the St. Lawrence area. Prof. Newberry speaks of large quantities of gravel and boulders having been carried through the waste weirs, penetrating the water-parting, and deposited in lines leading towards the valley of the Ohio, so that I infer such rock-fragments of lake-basin origin do abound within the limits of the Mississippi valley, and up to the line of Northern drift limit shown in the map.

(*To be continued in our next Number.*)

II.—CONGLOMERATE AT THE BASE OF THE LOWER KEUPER.

By J. SHIPMAN, ESQ.

RECENT excavations for buildings on the east side of Nottingham have afforded opportunities for observing the true character and development of the conglomerate at the base of the Lower Keuper, which did not exist when this district was visited by the Government Geological Survey. The fact that no fair equivalent of the Muschelkalk of Germany has been met with in England lends an interest to the beds at the junction of the Lower Keuper and the Upper Bunter which they would probably not otherwise possess. Thus the Geological Survey paid special attention to the scanty exposures of this junction that happened to exist twenty years ago in this part. The best section to be seen at that time, near Nottingham, was in a lane leading from the Mansfield turnpike road, a mile north of the town, to the Mapperley Hills, and is thus described by Mr. Aveline in his memoir on the Nottingham district (Sheet 71, N.E.) :—"Near the bottom of the lane there are beds of coarse sandstone [Upper Bunter] slightly consolidated, with pebbles of various coloured quartz, quartz-rock, and other sandstones. There is no good bedding visible in this conglomerate, and lying on it there are thin and regularly-bedded fine sandstones of a red colour. This is the bottom of the Lower Keuper beds, and the line between the two formations is well marked, there being an apparent unconformity. There is about twelve feet of this red sandstone, and above it three to four feet of soft red loam, then a thin bed of coarse light sandstone, above this a bed of sand and marl, with some small pebbles of quartz, then alternations of dark and light-brown soft sandstone of various thickness, and red marly shale, which pass up into the Upper Keuper red marly shale with thin beds of white sandstone." Between the Bunter conglomerate beds and the "thin and regularly-bedded fine sandstones" there comes a thin bed of conglomerate encrusting the slightly eroded surface of the former, which Mr. Aveline does not appear to have noticed, or, if he did, probably took it to form part of the Bunter. The only conglomerate Mr. Aveline appears to have seen was some sixteen or seventeen feet above the base of the Keuper. This conglomerate, however, although traceable all over the Keuper area east of Nottingham, consists of merely a few quartz-pebbles imbedded in yellow or greenish-white sandstone, never more than eight inches thick, and, unlike the conglomerate at the base, is not calcareous. It was not until two or three years ago that, discovering the calcareous nature of what had been always regarded as the top of the Bunter, I was led to examine the junction at other spots. Since then the further opening up of the ground along the line where the Keuper begins to overlap the Bunter has enabled me to collect tolerably complete data as to the development of the conglomerate in this neighbourhood. It may be here mentioned that chemical analysis has shown that the matrix contains a very large proportion of magnesia as well as lime. Generally the conglomerate is found to occupy the slightly angular, or rounded, shallow cavities of an eroded surface of Bunter, and as the Keuper reposes somewhat obliquely on the Bunter, there is an unmistakable unconformity. The conglomerate is thickest at its outcrop, and as it passes beneath the Keuper seems to lose some of its compactness, and, in one spot I have seen, is represented by pebbles stuck in a deep-red marly sand. Its usual development, however, is in the form of a ferruginous compact crystalline band, thickly studded with pebbles, and so hard that it is dreaded even by navvies; it varies in thickness between six inches and two feet, and is sometimes swollen by lenticular beds of coarse bleached sandstone as much as three feet thick. The most interesting exposure of it about Nottingham existed, until lately, on the Hunger Hill Road, and its character at this spot may be taken as fairly typical of its fullest development. The conglomerate itself consisted of pebbles, chiefly of quartz and quartz-rock, with fragments of trap, volcanic ash, claystone, greenstone, slate, chert, bits of yellowish limestone, permian magnesian limestone, and other rocks, with a good deal of calcareous matter coating some of the pebbles, in a ground-up form, and in minute crystals. Among the pebbles I found what seems to have once formed the extremity of a sea-worn pinnacle (for it was ribbed or fluted horizontally) of fine-grained greenish Cambrian (?) sandstone. Resting on the conglomerate was a thin bed of grit cemented into cakes by calcareous matter, then about two feet of bluish-grey soft bleached sand, irregularly bedded, but having a general slope at about 5°, and passing under the Keuper. False-bedding was shown here and there, with partings of strings of pebbles. In nothing but the absence of sea-shells did these beds differ from recent raised beaches met with on sandy coasts at the present day. The pebbles are all similar to those found in the Upper Bunter, while the sandstone is evidently redeposited Bunter; so this conglomerate may possibly throw some light on what happened in England during the interval between the



Lower Keuper, with the Conglomerate, resting on Bunter—Turner Street, Nottingham.

(Reduced from a pen and ink sketch by the author.)

Bunter and the Keuper subdivisions. The manner in which this conglomerate rests on the Bunter is well shown in the above sketch taken from a section in Turner Street, Nottingham.

The conglomerate is surmounted by thin and thick bedded red sandstone with marl partings. I have not attempted to trace this conglomerate farther north than Red Hill, four miles and a half from Nottingham. It is there seen, however, in a rather different form to what I have described it at Nottingham. Mr. Aveline thus refers to it:—"On the east of the road south of Red Hill may be seen some thick beds of very coarse half-consolidated sandstone of a yellow and reddish-brown colour, containing pebbles of quartz, and on these lie beds of red sandy marl with bands of fine-grained yellow sandstone; the lower coarse beds are the top of the Pebble Beds, the others the bottom of the Lower Keuper Sandstone. A few small pebbles occur near the bottom of the latter, but there is a very apparent difference between the two series of beds." When I first visited this spot, following Aveline, I, too, regarded the "thick beds" (about four feet thick) as Bunter; but on a second visit, after a long and careful study of the Keuper conglomerate at Nottingham, my suspicions were aroused by the striking resemblance between the thick beds studded with quartz-pebbles and precisely the same deep-red half-consolidated sandstone associated with the Keuper conglomerate, and a removal of the vegetation shrouding the lower part of the section revealed a compact ferruginous conglomerate, eight inches thick, *below* the massive bed of sandstone, and separated from the Bunter—a coarse yellow sandstone containing scarcely any pebbles—by about twelve inches of soft red marl. Of course this coarse red sandstone containing the quartz-pebbles was mapped as Bunter.

III.—ON CERTAIN ROCK-STRUCTURES, AS ILLUSTRATED BY PITCHSTONES AND FELSITES IN ARRAN.

By the Rev. T. G. BONNEY, M.A., F.G.S.;

Fellow and late Tutor of St. John's College, Cambridge.

IN a paper read on February 23rd, 1876, before the Geological Society of London,[1] I endeavoured to prove that the peculiar laminated or fissile structure, common in certain igneous rocks, was due to contraction, like the associated ordinary joint-structures. In the discussion which followed, an objection was made to my having quoted certain phonolites from Auvergne, in support of my theory, because it was well known that the fissile structure in the typical phonolites of Hungary was due to change in mineral composition, and so the result of a banded structure in the rock. That this was not the case with those Auvergne phonolites, I had already convinced myself by examination, both in the field and with the microscope, and I had nowhere asserted that the only way in which rocks could become fissile was by the particular cause which I had advanced; for, although I only knew the Hungary rocks from hand-specimens, I was aware of a somewhat similar structure in certain British rocks. I thought I remembered also one or two cases in these where the fissile and the banded structure were co-existent and independent, but as the criticism came from a quarter not to be neglected, I determined to re-examine these cases. This I have done on occasion of short visits to Arran in the past and present year, during which I have obtained materials which will, I think, further illustrate this, and throw some light on other rock structures. The points, then, upon which I shall touch in the present paper are the relation (I.) of fissile and banded structures; (II.) of banded, spherulitic, and perlitic structures.

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[1] Q.J.G.S. vol. xxxii. p. 140.

I.—*The Relation of Fissile and Banded Structures.*

I may commence by an additional instance of platy and joint structures. The great quartz-felsite[1] dyke on the Corriegills shore south of Brodick affords an excellent example. The outcrop of the dyke on the shore is about twenty yards wide, which probably corresponds to a vertical thickness of nearly ten yards; the base of the felsite for about eight feet is traversed by a series of platy joints, parallel to its surface, so that the rock splits up into tile-like pieces; above this a rude vertical prismatic jointing predominates. The upper part again is platy for about six feet, and just at the junction the jointing is very irregular, the platy structure seeming at one place to change for a short distance into a direction at right angles to the usual one. This is caused by the sudden predominance of a set of vertical joints. On following up the central part of the dyke, the joints curve considerably, as though they formed parts of the faces of large irregular spheroids. A basalt dyke breaks through between the base of the above felsite and the sandstone. It is, however, evident that the platy structure is not a true cleavage, due to the pressure of the basalt, because it has evidently been disturbed by

Pitchstones, Tormore shore.—The southernmost of these dykes exhibits banded, laminated and rudely columnar structure. The first is generally parallel to the upper and lower surface; so also is the second, but not invariably, as the two structures do not always correspond in direction, and occasionally cut at an angle of nearly 80°.

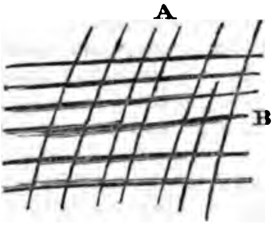

FIG. 1.—Diagram of intersection of streaky and laminated structure, from Lower Pitchstone, Dunfion.

A. Laminated structure, rather curved. B. Streaky structure.

A dyke of brown pitchstone to the north of the last, about four feet wide, shows banded structure very clearly on the southern side, where there is an intruded basalt dyke. This structure is barely, if at all visible on the northern.

The above cases seem to show that, though the fissile and banded structures are often coincident by reason of a common relation (which will be presently discussed) to the surface of the mass, yet they are of independent origin; and that the former is really only one special case of a series of phenomena due to contraction of the rock in cooling. Many other instances showing the relation of fissile structure to tabular and columnar jointing, and that between these and spheroidal structure, might readily be adduced from the various Arran rocks; but it is perhaps needless to multiply them. One curious case, however, in a pitchstone from Moneadhmhor Glen, may be worth a brief description, as well as a remarkable change in structure in the Birk Glen Pitchstone. The first of these pitchstones (exposed in two places in the stream, both apparently parts of one irregular bossy intrusion), is very closely and irregularly jointed, generally platy towards the exterior and passing into a columnar structure in the interior. A hand-specimen from the latter part illustrates the connexion between jointed and spheroidal structures. It exhibits three or four fairly well defined columns, while in other parts the joints have no definite direction. The largest column, about ¾ inch in diameter, exhibits an external platy structure; within this is seen at one end a very shallow cup, elliptical in outline. The other end shows an irregular dome-like ball. On following the surface of this downwards, it is seen, where becoming lost to view, to be again curving inwards, so that it resembles a rather distorted egg, partly sunk in the column. Somewhat similar structures are exhibited by the ends of the other columns. I conceive that this specimen supports my view of spheroidal and columnar structures, and shows that while they are due to the same cause, namely, contraction in cooling, they are partially independent.

The Birk Glen Pitchstone shows a very remarkable sudden change in the character of the rock. It is exposed in the bed of the burn, and again at about twenty yards distance by the pathway. There can be no doubt, though vegetation covers the intervening space, that these are parts of one and the same bed. The pitchstone in the burn is traversed by numerous joints, cutting it into rhomboidal prisms, from about $\frac{1}{3}$ to $\frac{3}{4}$ inch in diameter, one set of joints occasionally predominating a little, so as to give a laminated structure to the rock. So marked and persistent is this jointing, that it is almost impossible to obtain a specimen of any size. Under the microscope the rock appears as a glass, either full of very minute belonites, or exhibiting beautifully the batrachospermum-like groups,[1] surrounded by clearer spaces, with very few spherulites, and no banding of any kind. But the rock in the path has much fewer and less regular joints, it shows a distinctly streaky structure, and a great number of ill-defined spherulites, generally lying in the streaks. Under the microscope it shows the same belonitic structure as the other rock, except that this, as will be described below, is somewhat modified by the conspicuous banded and spherulitic structure. As a further proof of the identity of these two masses of rock, careful examination shows that the pitchstone, where last seen by the path, is becoming a little more regularly jointed, and in the bed of the stream we find one or two nodes, as it were, in which the regular jointing dies out, and a structure sets in, something like that seen in ill show that though this may often be the case, the mechanical rces produced by contraction have also sometimes an influence on it, and may even determine whether or not this structure shall set up.

The first case which I shall quote is not from Arran, but is exbited in a slide of liparite from the Lipari Islands. It is a poryritic rock containing many crystals of felspar, with a little quartz, otite, and iron-peroxide. An ordinary lens shows the dull white ound-mass to be traversed by a series of more transparent lines viding it up into polygons, so that it looks like a miniature represenion of a columnar-jointed surface. Inside the polygons, the rock hibits a faint radial structure. Under the microscope these cracks pear to have been true minute divisional surfaces, though they now em to be closed by a generally paler mineral deposit, which is rk between crossed prisms. Sometimes also we see a thin dark ie, bordered on each side by a clear space. The interior of the lygons commonly exhibits very clearly the usual fibrous radial ucture;[1] but in some of the smaller it is very ill-defined. In me cases we note a kind of circle inscribed in the polygon, within ich the radial structure is more marked; generally there is no cleus visible in the spheroids, though now and then they seem become rather more crystalline on approaching the centre; nor do ey appear to have any very immediate relations with the larger bedded crystals (compare Fig. 3).

Passing next to a perlitic pitchstone from Meissen, we observe at it exhibits a flow-like structure, indicated by wavy bands (in tline like some cirrus clouds), produced by innumerable very nute opaque microliths. Through these the perlitic structure ts with perfect independence. There are no spherulites to be seen the slide. A perlite, also, from Glashütte (Schemnitz), shows very ll this wavy flow-structure; but here the bands are so conspicuous d clearly marked that the rock looks like a miniature model of a ntorted gneiss. A few spherulites occur in this, which in most ses, though not in all, seem connected with the larger crystals curring in the matrix.

The great pitchstone vein on the Corriegills shore exhibits, as has en said, faint indications of a banded structure. Under the micrope it appears full of a microlithic dust with larger belonites gly or in groups, surrounded by slightly clearer spaces; a good ny of these belonites are roughly parallel. The smaller vein has also lications of banding, though slighter, with a similar microscopic ucture; but the clearer spaces are larger, and themselves indicate ind of banding. There are one or two spherulites surrounded by a earer ring. More distinct bands are seen in the lower pitchstone vein Dundhu, and some of the dykes of the Tormore shore, the micropic structure of which is excellently depicted by Mr. S. Allport,[2] o says (p. 6), "The rock is simply a continuous homogeneous ss, in which the devitrified or crystallized particles have arranged themselves in alternate layers characterized by differences in texture only." The southern dyke at Tormore seems to indicate that the banding is here caused by the more complete crystallization of the augitic constituent, the fine dust having almost disappeared from the glass with a marked increase in the number of belonites; there are also several spherules. The pitchstone by the path in Birk Glen shows some fairly regular isolated bands of yellowish glass, together with several more irregular patches. In no case, however, have the ends of these a torn or "teazed" look, as if they had been subjected to strain; some indeed are quite round. Belonites occur in both the clear and the yellow glass, sometimes singly, but commonly with the usual alga-like aggregates. They pass from the clear to the yellow glass, sometimes, however, being a little crowded on the surface of the latter, as though they stuck in a denser fluid. In it also the lateral microliths are less clearly defined, as though the side branches had fallen from the main stem of the plant, and had been replaced by a lichen growth. With polarized light these bands show an imperfect spherulitic structure, as do some of the rounded spots. In the former, however, there is no indication of any disturbance of the spherulitic structure, that is, it does not appear as if one or more spherules had been elongated into a band, but as if a line of imperfect spherules had formed out of a band.

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[1] See Mr. S. Allport, Geol. Mag. Dec. I. Vol. IX. p. 541.

[2] Geol. Mag. Dec. I. Vol. IX. Pl. I. Fig. 2.

The first pitchstone on the shore south of King's Cove gives indications of a rough perlitic structure. Under the microscope this appears more as a polygonal network of exceedingly minute cracks than as the ordinary perlitic structure. There are irregular bands and cloudy spots of yellow glass; the latter frequently showing rings of darker glass, which, on examination, prove to be roughly concentric with the above reticulations. With crossed prisms these rings prove to be the boundaries of more or less perfect spherules. This rock does not show the alga-like tufts, but has numerous scattered belonites about ·001 inch long. These often pass indifferently into the spherulites, but are sometimes arranged radiately. There are a good many larger crystals scattered about, chiefly of sanidine; some of which (but not all) show a growth of belonites perpendicular to their surface, and a radial structure of the surrounding mass. A pitchstone, from an erratic,[1] on the Old Lamlash Road, also shows a similar spherulitic growth on some of the larger crystals contained, but here also this structure is visible in many isolated patches of brown glass.

The larger crystals occurring in the pitchstones sometimes, as described by Mr. Allport, include portions of the glassy matrix, but rarely, if ever, well-defined belonites. Sometimes they have evidently been broken, and the fragments lie close together. They appear then to be the first things formed in the rock, and perhaps may sometimes be very much anterior to the solidification of the ground-mass.[2]

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[1] I am not aware that the locality where this occurs *in situ* is known. It is the same rock as is described by Mr. Allport from a boulder occurring near W. Benan (GEOL. MAG. Dec. I. Vol. IX. p. 537).

[2] I have observed in numerous instances in trachytes, felsites, etc., that the forma-

Reviewing then the above facts, we seem justified in asserting that in some of the pitchstones there is the following succession of phenomena—1. The formation of the larger porphyritic crystals; 2. The differentiation of the matrix, which produces the streaky or banded structure; 3. The formation of the belonites; 4. The aggregation of them into the alga-like clusters; 5. The formation of spherules. Of these, 1 and 2 as a rule take place before the motion of the rock as a mass is quite arrested, though probably it has attained a pasty condition, and—at least in 2—the position of its molecules in space is not greatly altered subsequently. With regard to 3 and 4, the evidence is more conflicting; the belonites sometimes giving evidence of subsequent pressure or strain, sometimes of having formed in a mass in equilibrium; 5 has occurred—and in connexion with it the perlitic structure—when all motion except molecular has become impossible.

Passing now to the felsites, we find an interesting case on the shore north of Drumadoon; there a dyke of compact felsite is divided from another mass of porphyritic felsite by a branching dyke of basalt (see Fig. 2). The former felsite is very flaggy, with some slight appearance of a generally minute spherulitic structure, but the character of the rock changes for the last half-yard or so adjacent to the basalt; here the flaggy structure is lost, the rock becoming massive, of porcellanous aspect, with well-defined spherulitic structure. On examining a surface of this carefully, we see a polygonal network, indicated often by darker lines, and within each reticulation one or more well-defined spherules. Under the microscope (Fig. 3) we see the network indicated clearly by darkish lines; sometimes faint, but oftener well-defined, like a string overgrown with dusty mould. The inner circles are marked with fainter lines of the same. On crossing the prisms, we see the structure

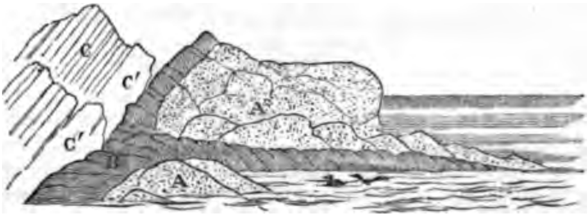

FIG. 2.—Dykes near Drumadoon Point.

A. Porphyritic Felsite. B. Basalt. C. Compact Felsite.
C′. Spherulitic Felsite.

tion of the larger crystals of felspar and some other minerals seems anterior to the setting up of microlithic structure. Can it be that in many cases these have been formed in some prior cooling of the rock, and that the last elevation of temperature previous to the ejection of the rock only fused the ground-mass? Except on some such theory it is very hard to explain such cases as are found in some of the coarser leucite lavas of Vesuvius.

described by Mr. S. Allport,[1] namely, a felsitic structure outside the circle, and a fibrous radial structure inside, the division between them not being quite so sharp or regular as it appeared before. By searching about the slide we can find almost every stage, from the setting up of the fibrous radial structure at a point in the matrix, to a spherule with a well-defined circular boundary. There is no evidence that a nucleus of a different mineral character is needed for the formation of a spherule.

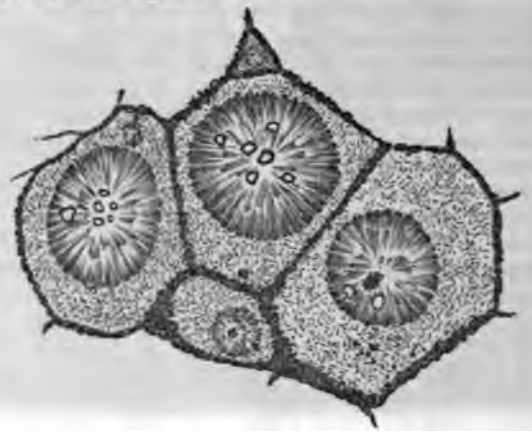

FIG. 3.—Spherulitic Felsite. Diagrammatic sketch from microscope. The radial structure in the spherulites is rather exaggerated; the exterior granulated part with both prisms shows 'felsitic' structure, sometimes with slight radial tendency, the polygons are defined by opaque clotted (ferruginous?) dust.

The next rock to be examined is the spherulitic felsite on the Corriegills shore. It has been noticed by Macculloch and others, and its microscopic structure has been excellently described by Mr. S. Allport; but still its relations to the neighbouring rocks do not seem to have been fully worked out, so that I must describe it at some length, as these seem to throw much light on the formation of some of the above structures. A compact felsite dyke about 12 yards across is exposed on the shore, and can afterwards be traced running up the inland cliff. Here a pitchstone vein, rather more than a yard thick, separates it from the sandstone beneath. At the base of the cliff both are lost for a time under vegetation; but when this ceases, we find the pitchstone still beneath the felsite. The latter shows a rather platy structure for about three or four feet, top and bottom, most distinct at the latter, being irregularly jointed elsewhere. Generally the felsite is much decomposed, of a pale cream colour, with ferruginous brown stainings, in appearance rather like a soft fine sandstone. The base, however, above the pitchstone, as will presently be described, is much indurated. The pitchstone now thins away, and some irregular outcrops of a greenish spherulitic felsite make their appearance. These occur chiefly in two little bays in the sandstone about four yards apart. The one further from the sea shows (I.) the laminated base of the felstone; (II.) the same of a vitrified aspect, and streaky, rather spherulitic structure; (III.) pitchstone; (IV.) spherulitic felsite (Fig. 4). The last has fewer spherules at top and bottom. No one of these three rocks is in absolute contact, each being separated by a foot or two of debris. It is not quite certain either whether this particular piece of pitchstone is really *in situ*, as it is separated from the rest of the vein, but, so far as I could make out, by clearing away the rubbish, it seemed to be. In the southern bay there is only the spherulitic felsite underlying the indurated base of the felsite. The question then which first suggests itself is the following, Is the spherulitic felsite a special condition of the ordinary felsite or of the pitchstone, or a third and distinct intrusive rock? The evidence is as follows: A passage between the pitchstone and the spherulitic felsite is nowhere seen, though the former seems to have rather more spherules towards its base, and the latter rather fewer spherules top and bottom; the decomposed state of the two rocks being very similar, each forming a brittle grey putty-like clay. The spherulitic felsite, however, cannot be quite identical with the pitchstone, because it has a different behaviour, showing a peculiar ropy structure, like some lavas, on its outer surface, and adhering to the sandstone, where it is last seen, in a thin skin, with an appearance of viscid flowing, difficult to describe, but very remarkable. Near here we find it apparently attached to the partly vitrified base of the ordinary felsite. This at first sight looked like a junction of two distinct rocks; undoubted ordinary felsite (though indurated and altered) being within an inch of fairly characteristic spherulitic felsite: but careful study of the specimen and microscopic examination fail to detect a perfectly clear line of demarcation. Further, on the south side of the felsite dyke, are two or three small irregular intrusive-looking masses of rock, which, on close examination, seems to be the spherulitic felsite in a highly decomposed condition; the matrix of part being stained a light dull red; part being quite sandy and cream-coloured, like the other felsite. Still, in its mode of occurrence, it resembles the spherulitic felsite on the opposite side, and the spherules in places yet remain fairly distinct.

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[1] GEOL. MAG. Dec. I. Vol. IX. p. 541.

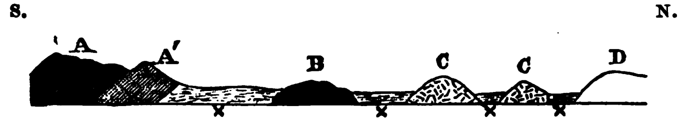

Fig. 4.—Section showing relation of Felsite and Pitchstone on Corriegills shore.

A. Flaggy Felsite.
A′. Vitrified base of Felsite.
B. Pitchstone.
C. Spherulitic Felsite.
D. Sandstone.
X. Débris.

On examining the base of the felsite in the cliff over the pitchstone, I found it exhibited a vitrified appearance and banded structure, with numerous not very clearly defined small spherules, and a peculiar structure on the surface of the base, as if it were studded with half spherules arranged in lines or sometimes agglutinated into mounds. I have a slab from the very base, about 1¼ inch thick, which shows this structure on both surfaces; the lower being the coarser; the upper in its fine parallel arrangement almost resembling a piece of wood beneath the bark.

The microscopic structure has been so minutely described by Mr. Allport that I cannot do better than quote his words.[1] "In a very thin section, in ordinary light, the spheres exhibit a well-defined circle, bounded by a line of minute grains of iron oxide, but the fibrous structure is not so distinct; in fact, it then appears to be simply a radial arrangement of the particles of a fine dust scattered through a dull uniform base; dark greenish aggregations of this substance sometimes form an irregular nucleus, throwing off rays towards the circumference; frequently, however, the centre is free from them, and there is then no appearance of any sort of structure. These green patches also occur in the matrix, and both spheres and matrix appear to be composed of precisely the same substance. Placed between crossed nicols the appearance is completely changed, and it is at once seen that the matrix has a felsitic structure,[2] and that some of the spheres are also composed of portions of the same substance, which have, however, undergone a process of aggregation and radial arrangement in globular masses; but the felsitic structure is still quite as evident as in the base. Many of the spheres are, however, composed of two or more concentric layers; in some there is a felsitic nucleus surrounded by radiating groups of green dust; in others the nucleus consists of grains of quartz only." I may add that where spherulites are in contact, there is a divisional line between them, as in the Lipari and Drumadoon specimens, and sometimes the spaces between the polygonal boundary lines and the circle show a structure intermediate between the normal felsitic and the true radial; also that this spherulitic felsite exhibits great variety of structure; a piece taken at the distance of a yard from one of the parts where these spherulites are best developed showing comparatively few of them, and these very small, often imperfect, and with a linear arrangement. A slide from this last specimen shows that the felsitic structure mentioned by Mr. Allport prevails in most parts; and the spherulites are isolated and not very well developed; a slight banded structure is apparent in the rock; and here and there also a curious structure something like a lichen or dendritic growth.

A slice cut vertically from the slab at the base of the felsite in the cliff shows that this structure prevails throughout it. With crossed prisms the effect is really pretty, a peculiar arborescent growth, like some lichens or sea-weeds, standing out with a sort of stereoscopic effect in various tints of milky grey against a dark ground. Here and there is a trace of spherulitic structure, and the bands, which are not nearly so distinct under the microscope, have rather a streaky aspect. A slice from the base of the felsite on the shore, where it approaches most nearly in appearance to the spherulitic felsite, shows an irregular banded structure; wavy, mossy, brown bands and elongated streaks of brown dust, giving it somewhat the appearance of a slice of agate; the latter are full of tolerably clear spherules, sometimes isolated, sometimes crowded; with crossed prisms these show very clearly radial polarization. In parts of the slide, the dendritic structure described above may be seen; it is more brightly coloured than in the last; in fact one constituent (quartz ?) in this slide seems to be more distinctly crystalline and the other more earthy than in that specimen.

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[1] Geol. Mag. Dec. I. Vol. IX. p. 541.

[2] Exactly the same structure is seen in the felsite from near Drumadoon, mentioned above.

With regard then to this particular rock, the spherulitic felsite, the evidence seems to show that it is more closely related to the felsite than to the pitchstone,[1] but that it is not merely a portion of the felsite altered *in situ*. It appears to have distinctly flowed at a period subsequent to the intrusion of the ordinary felsite. In this respect its relation seems closer to the pitchstone. It is evidently a rock of extremely local occurrence. I conclude therefore that the pitchstone, which has everywhere very highly altered the felsite in contact with it, has in one or two places actually melted it down, so that the liquefied mass flowed for a short distance before solidifying again. The regularity of the spherules shows that they did not begin to form till the mass was wholly at rest.

Reviewing then the whole of the evidence, it would appear as if spherulitic structure were generally one of the very last to be set up, so as to be even capable of being produced in a rock by a temperature a little lower than that which would actually melt it.

The above observations also seem to throw some light on the cause which produces it. This seems generally to be vaguely stated as 'concretionary,' or the result of crystalline forces; devitrification being often supposed to be started by the accidental presence of some foreign body at the central point. The above examples suggest a more definite explanation, which may at any rate hold good in numerous cases. That spherulites are formed at all may be due primarily to very slight differences either in mineral composition in that part of the glass,[2] or in the rate or mode of cooling. What we have noticed seems to show that only very rarely had they any connexion with included substances, and suggests that they have rather grown inward than outward. Suppose then a cooling mass, already in a semi-solid condition, to be losing heat very slowly and uniformly in all directions, it will thus be thrown into a state of strain from contraction, and will have a tendency to break up into fragments. The great facility with which spheres are formed under contractile strain will render a perlitic structure a very common result,[1] but seeing that obviously space cannot be entirely filled by spherical surfaces, fracture into regular polyhedrons is likely to result, the form of which, in accordance with the principle of least action, will be rhombic dodecahedrons.

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[1] I am indebted to a college friend for the following additional evidence. The spherulitic felsite agrees in composition more closely with the other felsite (allowing for its state) than with the pitchstone; the last having at least 2 per cent. less SiO_2. Again, when the powder of all three is heated to redness for about 10 m., that of the two felsites does not cohere, and afterwards cannot be distinguished in colour—being an ochreous grey; while that of the pitchstone coheres and is brownish stone-grey. Again, on fusing both the spherulitic felsite and the pitchstone with (K. Na.) CO_3, the former assumes a yellowish-green tinge, and the latter a rather clear bright green, showing there is more Mn or less Fe in it. The pitchstone also (though the coarser powder) decomposed readily with the fusing mixture, while both the felsites left a residue, which required prolonged fusion.

[2] As when we find them associated with the brown glass of pitchstones.

Consider now the case of a single one of these, and suppose it to go on very gradually losing heat uniformly from its exterior, then, just as I have shown happens in the case of spheroidal structure on a larger scale, the surfaces of equal tension will be approximately spherical. As the mass contracts, all the particles in any one of these surfaces will be simultaneously acted upon by an equal central force: if then the temperature, pressure, etc., be such that microlithic crystallization is set up, the crystals will grow towards the centre, because both that is the direction of the normal force, and the surface of crystallizing temperature is approaching the centre. There is thus a certain analogy with the growth of radiating columns in a spheroidal mass of igneous rock, like the spindle at St. Andrews. The nucleus, when present, is therefore more often likely to be a residuum than an included foreign body. As the mass is in a state of normal strain, it may once or twice rupture along a concentric surface during the formation of the spherule, and this may account for the concentric layers in the spherules. Certainly these are not seldom surfaces of weak cohesion, because the spherule exfoliates easily along them, and they are often covered with a sort of white dust. There is thus a common cause in the development of perlitic and spherulitic structure, namely, a contractile force, but this in the latter case is acting on a crystallizing body. I think, however, that the same explanation will apply to the spherules which do not show a crystalline structure, and probably to some of the larger felsitic balls in igneous rocks, the outer surface denoting a surface of equal force, which has caused the part within to assume a structure (not necessarily crystalline) different from that without. Further, it will be obvious that the process of formation of a line or band of spherules will be analogous to the formation of spheroidal structure in a column of an igneous rock, especially to that case where the spheroids are formed without external rupture of the column.

Some of the above evidence, such as the banding of pitchstones towards the exterior, and one at least of the banded felsites, also seems to show that this latter structure may be the result of squeezing, not of flowing; the same result, as I have pointed out in another case,[2] being produced by diverse forces. The former cause is likely to produce the more regular structure; for it will be readily seen that if a number of particles, not homogeneous, are mixed together, and then squeezed, so as to be forced to pack into smaller space, there will be a kind of rhythmic arrangement, like getting with like, in alternate order.[1] The effect then of contraction due to cooling is probably much greater in producing rock structures than has been generally supposed. Since, however, the chemical composition, and the circumstances of solidification, vary so greatly in igneous rocks, and a very slight difference in the circumstances may produce with these minute structures a very appreciable alteration in the results, we must not be surprised if cases should occur to which we cannot apply the above explanations, at any rate without considerable modification.

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[1] See Quart Journ. Geol. Soc. vol. xxxi. p. 152.

[2] *loc. cit.* p. 153.

IV.—ACROSS EUROPE AND ASIA.—TRAVELLING NOTES.

By Professor JOHN MILNE, F.G.S.;
Imperial College of Engineering, Tokei, Japan.

(Continued from p. 468.)

Part VI.—Tomsk to Irkutsk.

CONTENTS.—Tomsk to Krasnojarsk—Appearance of the Country—Flint Implements at Kansk—Pre-historic Remains in Siberia, probably the 'Spoor' of a race allied to the Eskimo—Geology in the neighbourhood of Irkutsk—Cold of Irkutsk.

THE day on which I arrived at Tomsk, which was the 6th of October, I bought a small tarantass, and next morning I started, with some who had been fellow-passengers on the steamer, *en route* for Irkutsk. There were four conveyances between three parties, one of them being used exclusively for baggage. As each of these always needed three horses, and sometimes four, we often had difficulties at the post-station, where the post-master seemed disinclined to allow such a sudden draft being made upon his stables. Luckily my friends were high officials, and travelling on Government service, and their wants had from necessity to be supplied. My carriage being included with the rest, I went along comfortably and without delay, which would most certainly have occurred had I been alone. Before we were fairly outside Tomsk we ascended what I had, when at a distance, mistaken for hills, but which now appeared to be only a scarp-like face of a plateau, and we were soon upon a dusty road bounded by a low plantation of birch. Now and then we plunged down and over a small water-course, our momentum always carrying us some distance up the other side. Everywhere the country appeared as if it were an alluvial expanse; but in the vicinity I think there must have been some beds of rock, because everywhere along the road stone was being used as a material to repair it. This was yellow, argillaceous, and somewhat slaty in its character, perhaps having come from some of the Coal-measures which I believe exist in the vicinity of Tomsk. The birch-trees were now destitute even of their withered leaves, and the only relics of the falling year were a few white heads of a *Millefolium* and brown tufts of faded grass. During our first day upon the road we met a number of carts carrying a white clay, used in Tomsk for the manufacture of pottery. We travelled day and night, stopping every two or three hours at some post-station to obtain a change of horses. I now noticed that the birch-trees were only growing upon the land which had been cleared on either side of the road; far behind them I could see the dark frontage of woods of fir. The evergreen, on being cut down, had evidently given way, whilst trees, like birch and aspen, had sprung up in its place, giving us an example of that succession in growth which sometimes takes place in the Vegetable Kingdom, and which Lyell and others have represented as having taken place in pre-historic Denmark and in other countries. Every night we now had frosts, and it was necessary to wrap up warmly, whilst every morning the sun streamed in at the open mouth of our tarantass to take off the chill of night, and remind us that it was Eastward Ho that we were travelling.

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[1] With this compare the "veined structure" in glacier ice, as explained by Prof. Tyndall, Glaciers of the Alps, p. 376.

On the morning of the 27th at last I saw real hills. They were large and smooth in outline. Separating us from them there was a valley filled with mist, between the patches of which small stretches of a shining river could now and then be seen.

As we were entering a village called Bojotol, at about 9.30 A.M., one of our carriages happening to break down, I had an opportunity given to me to walk down to the river I had seen, which I learnt was called the Chulim. In a bend upon the side towards which the water flowed, there were banks 20–30 feet in height. The upper layer of these was of black earth, about 1½ feet in thickness, beneath which came a yellowish clay, which readily crumbled when it was dry. In this latter, which formed the remainder of the bank, about six feet from the top, I found a lower jaw of some small rodent like a Squirrel. This was unfortunately so friable that it broke whilst it was being transported. Two feet below this there was a band of clayey concretions. Two feet still lower I found a number of fragmentary bones, only the articulating heads of which were preserved. They were apparently those of an animal like an Ox. Beneath this bone band there was a bed of bluish clay, from which a talus sloped downwards to the water's edge, hiding all that was beneath. After the difficulties of carriage mending had been overcome. we proceeded on our journey. Some miles farther on the road I saw another section in the banks of the same river, which I have just described. It was, however, twice as thick, and was made up of beds which were very sandy. In the afternoon we passed a square post standing by the side of the road, which marked the division between the governments of East and West Siberia, and the same evening we entered the town of Artchinsk. Before night came on I had time to see that there were a few low hills in the neighbourhood, but these, I think, like those at Tobolsk, were made of alluvial material. Next afternoon, just before we reached Krasnojarsk, which I looked upon as the halfway house upon our tiresome carriage journey, we entered on a hilly country. It was very open, which, with its want of trees, together with its smooth curving contour-lines, gave to it an appearance not unlike our English Downs. For a considerable time whilst we were rolling along the roads between these gentle slopes, we had before us a view of two very remarkable-looking peaks, which were in shape like Egyptian pyramids. These, however, by the time we had reached Krasnojarsk, which was early in the afternoon, had so changed in their appearance that they were only like towering ragged rocks. Near the entrance to the town I saw upon my right a scarp of reddish rocks.

Instead of doing as I ought to have done, and gone for a scramble among the surrounding hills, I joined my friends in accepting an invitation to sup at the house of the military governor. Here the effects of four days' and four nights' continuous jolting very naturally resulted in my falling asleep in the drawing-room of my host. Before midday next morning we were again upon the move. The River Yenesei, which we crossed just outside the town, is both broad and rapid. On the opposite side of the river there is a range of sharply-pointed hills, amongst the peaks of which I think I recognized my pyramids of the previous day. Between the river and the foot of these hills, there is a narrow line of cultivation. For some distance outside Krasnojarsk there was a continuity of cultivated land, and we had many pretty views of pine-clad hills, which looked down upon villages and fields in the valleys which they bounded.

On the 29th we passed through the little town of Kansk, a short distance beyond which we ferried over the little river Kam. It is so clear that all across you can see its pebbly bottom. These pebbles are mostly siliceous, such stones as Flint, Jasper, and Agate being common. On the opposite shore we were faced by a steep bank, at least thirty feet in height, to the top of which we ascended through a cutting. It was made up of a yellowish sandy soil, with here and there a small patch of bluish clay. Growing on its slope there was a stunted sweet-smelling *Artemisia*, and a small succulent broad-leaved plant like a house-leek, whilst in the water below there were beds of water-weed. Near the top of the embankment the soil assumed a fine sandy character, which gradually merged into a black earth. In one or two places, when these came together, I found fragments of bone and chipped flints. With these there were many pieces of burnt wood. Some few of the flints were in the form of rough arrow-heads without fangs, but the greater number were simply chips. In different parts of Siberia large quantities of the remains of the early inhabitants have been found. In the Museum at Irkutsk I saw many which had been brought to light whilst making excavations in the vicinity of the town. Thus, whilst digging the foundations for a new military hospital on the banks of the River Ooshakofka, a tributary of the Angara, in addition to stone arrows and fragments of coarse pottery, a number of implements and ornaments were also found. These latter were made from ivory, which is apparently that of the Mammoth. One of these resembles a dice box (or the head of a croquet-mallet), but differs slightly in the diameter of its two extremities, and is not hollow. The diameter of one end is 34 mil., and the other end 29 mil. The length is, I believe, 71 mil. In the centre of this a hole has been bored, which, from its conical shape, looks as if it had been rymed out by means of a flake of flint.[1] Round the diameter of this, circular bands have been deeply scratched. Another curiously-shaped article is spheroidal in form, the two diameters being respectively 45 and 58 mil. Upon it, as upon the cylindrical body which has been just described, there are bands of circles traversing its surface in different directions. The use of these articles does not appear to be known. They were found in clay at about the depth of 2½ mètres, and were accompanied by shells like *Pupa*, *Helix*, and *Succinea*, indicating freshwater and terrestrial conditions. In addition to these I also saw many other relics of bygone times. Amongst these there were many gouge-shaped stone chisels, like those which are dug up in Japan, Newfoundland, and many parts of North America. These, I believe, were used to dress skins with in a manner similar to that in which a Micmac now performs the same operation with a knife. There were also some teeth of *Cervus elaphus*, which had holes bored through them, bones of *Equus caballus* and *Bison priscus*. From the comparison of these beds with others also in the vicinity of the town, where the remains of the Mammoth have been found, Mr. Tschersky, their discoverer and describer, appears to think that they in all probability belong to a Middle Stone period.

Besides those animals which I have just mentioned, others, which are conspicuous amongst the list of European Pleistocene mammalia, have also been found in the vicinity of Irkutsk. Thus we have *Elephas primigenius*, *Rhinoceros tichorhinus*, *Equus caballus*, *Cervus tarandus*, *Cervus elaphus*, *Cervus capreolus*, and very many others.

Prof. Boyd Dawkins shows that the Palæolithic cave-dwellers of Europe have a blood relation with the Eskimos of North America, a view which is chiefly founded on the fact that these two races, which are now removed so far by both space and time, apparently used the same set of implements, a condition which at the present day only exists between blood-related tribes. The Musk-sheep and Reindeer which now give food to the Eskimo, having also furnished food to the early cave-dwellers, strengthens the idea,—and it was as these animals retreated from Europe across Asia towards the north-east, that man retreated also. The bones of these animals, as Mr. Boyd Dawkins tells us, together with those that I mentioned, mark the line of this retreat across Siberia. The flint implements that I found upon the Kan, together with others of like kind from neighbouring localities, tell us that certain implement-forming minerals were everywhere sought out and utilized by primitive Man, who, chipping them into weapons at each convenient resting-place, has thereby left his spoor. If this migration is a fact, and it seems, when all the evidence is considered, to be probable enough, then it may be correlated with those periods of great cold to which I have already several times referred.

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[1] The specimens are figured by Mr. Tschersky, who has also described them in the Proceedings of the Geographical Society of Irkutsk, Sept. 18th, 1872.

In the first portion of my journey across Sweden, and along Finland, I described the ice-worn aspect which these countries present, which I, in part, justly attributed to the action of coast-ice on a rising area. I then made reference to the indications that we have, both here and farther south, of the higher lands and valleys being covered with glacier-ice. In some places new ones were freshly formed, whilst in other places pre-existing ones were augmented, so that, as Prof. Ramsay tells us, we had, for example, in the Alps glaciers perhaps 3500 feet in thickness. All this implied an intensification of modern agencies. Farther on, upon the section of my journey across the Siberian steppes, I intimated that indications of an ice-cap, or of conditions so severe as they appear to have been in Europe, are at present wanting, and, therefore, until we have really found them, their existence rests on debatable evidence. Adopting the above views, the tracks of Palæolithic man, and of the animals which were contemporary with him, which are being brought to light in Siberia, may be taken as congruent phenomena, and we may suppose that they retreated from a climate, which in Western Europe was by its severity driving them towards the south, and escaped to one more suited to their conditions. That they retreated directly towards the north as the cold retreated, at present hardly appears to have been the case, because remains of a Palæolithic type do not appear to have been collected from those countries, like Denmark and Scandinavia, where they would naturally be expected to occur.

With this speculation upon the cause of migration, which migration was in itself more or less of a speculation, I will stop, and return to my track upon the road to Irkutsk from which I have so far wandered. The country beyond the River Kan is undulating, and is thickly covered with both pine and birch. As the road sometimes led us along the tops of ridges, we occasionally obtained extensive views. In the afternoon we crossed a morass upon a road which was kept in its place by a row of piles driven in about three feet apart upon either side. Every morning we stopped at the first station we reached after daybreak to warm ourselves and drink tea. At these places we had excellent opportunities for observing a red species of cock-roach with which the walls of the station-house were thickly covered. On the following night, 1st of November, it snowed heavily, and by the morning the ground was so thickly covered that the rapidity of our progress was greatly impeded. The surrounding hills were now higher. Owing to a thaw during the day and a frost at night, the sides of many of the hills which we had to cross became so slippery that it was often doubtful whether we should reach their summits, and much of the night was spent walking alongside our struggling horses. One horse we had to leave for dead. On the 4th it rained and blew heavily, and, in spite of all our endeavours, the rain forced an entrance to our tarantass. On the evening of the same day, about 5 P.M., we reached the shores of the rapidly flowing Angara, on the opposite side of which we could see the glimmering lights of the houses in Irkutsk. In less than an hour we had crossed the flying bridge, and were safely at the end of this section of my journey: the distance from Tomsk being about 1559 versts, or 1036 English miles. Irkutsk is a large town, of about 30,000 inhabitants, containing many fairly handsome buildings. It is situated on the N.E. side of the Angara, opposite to its junction with the River Irkut. Like St. Petersburg, it may be said to have been built upon a marsh. In 1652 there were only two houses upon the present site, but soon after, in 1686, by order of the Government, the town as it now appears began to rise. Although the town itself is flat, the surrounding country is undulating. All along the sides of the rivers, and running for some distance up the slopes of the hills, there are beds of alluvium. On the hills themselves there is a covering of yellowish earth from two to three feet in thickness, which, from the fragmentary stones it contains, can be seen to have been derived from the disintegration of the subjacent rocks. These are in the main a grey and yellowish sandstone, slightly micaceous, and somewhat gritty. This is quarried and used as a building stone in the few places where stone is required about the town. In some places it is conglomeratic. Whilst examining this rock upon the north-east side of the town, I found several thin vein-like seams of coal. These veins, which had a brownish lignitic character, were from two to four inches in thickness. In the surrounding districts many outcrops of this material have been found, which unfortunately appears to lack more in quality than it does in quantity. From fossils which have been found in this formation, its age, as I have before stated, when speaking of the coal-fields of the Urals, is probably Jurassic. About 40 miles to the north-west this

Two days after my arrival in Irkutsk snow again fell, and this time it covered the ground so deeply that all my outdoor work came to an end.

In Irkutsk there are two museums. One of these is attached to a Technological School, and is used for teaching purposes, and the other is at the rooms of the local Geographical Society, which acts as a branch of the larger Society in St. Petersburg. In this latter there are many objects of great interest. Amongst the minerals, fine crystals of Uilnite and Onvarovite are the most noticeable. In the osteological collection the bones of Deer and of the Mammoth seem to preponderate. Some of the latter had integument still remaining on them. In the Technological Museum there are some remains of the same animal, which, in addition to the integument, have also a good coating of long red hair, eight inches in length. I also saw several skulls of Tigers from the Amoor district, and Seals from Lake Baikal, together with a long series of Crustacea, which also appear to be peculiar to this lake. Of especial interest to the Zoologist and Palæontologist are a number of mummified remains of various animals, which have been obtained from a cave near Nijni Udinsk. As the temperature of this cave appears never to rise above — 4° C., the creatures that have died in it have had a great portion of their integument preserved. The results obtained from exploring such caves, and a number of them appear to have been discovered in these localities, will probably be of great interest, as it will give us a surer insight into the softer parts of many animals with which we have only hitherto been acquainted from their bones. In the museum there is also a small collection of birds and quadrupeds, some insects and fossils, and an antiquarian assemblage of dresses and implements. During my stay in Irkutsk, which was for about a month, the weather gradually grew colder. One night the thermometer sank to — 28° R. (— 31° F.). Notwithstanding the deadening influence of this cold at night-time, the stars looked brighter and more cheerful than I had ever before seen them, and when the moon was up it was so light, that I could read without difficulty small handbills posted on the walls. The cold was, however, too great to be enjoyed. During the day the appearances were reversed, and the town, especially during the dull weather, was both melancholy and depressing. The smoke from the chimneys, instead of rising to be dispersed in airy clouds, rolled heavily from the chimney tops in a long black horizontal line, and then fell down towards the ground. Its quantity seemed to be increased, which was perhaps due to condensation of the aqueous vapour. When you opened a door, the cold air rushing in condensed all with which it mingled like so much smoke, which rolled across the floor in fuming clouds. If the sun shone brightly, you could often see spicules of ice glittering in its beams.

Although I felt great cold whilst staying in Irkutsk, I did not experience anything like the extreme cold which this district annually experiences. The greatest cold registered during the preceding winter was — 39·5 R., and the greatest warmth during summer was + 21·75 R., which gives a range of 61·25 R., or of 137·8 F. The average temperature in winter at Irkutsk is — 14°·8 R., and the average for summer + 13·1 R. For the whole year the average is — ·4 R., indicating that as a whole the gay society of Irkutsk live in a freezing temperature. Farther to the north at Yakutsk the average temperature is — 8·6° R., whilst still farther upon the borders of the Arctic Ocean at Ust Yansk it is — 13·0° R.

(To be continued in our next Number.)

NOTICES OF MEMOIRS.

PROFESSOR TOULA ON THE GEOLOGY OF ST. NICOLAS-BALKAN: Section OSMANICH-AK-PALANKA. (Proceedings of the Imperial Academy of Vienna, April 25th, 1877.)

[Communicated by Count MARSCHALL, F.C.G.S., etc.]

THE central massif is composed of crystalline unstratified rocks, of granite (St.-Nicolas Defile: altitude 1390 mètres), and very extensive dioritic rocks. Azoic rocks, such as clay-slates and gneissic rocks, with intercalations of chloritic and quartzitic schists, appear both on the south, and especially the north slope. In this direction they extend as far as the River Arcer, where they are partly overlain by "Sarmatic" deposits. The Carboniferous sandstones south of Belgradeik, on the northern slope, include organic remains characteristic of the Old Red ("Walchian") sandstones, as *Calamites*, *Annulariæ*, *Odontopteris obtusa*, Naum., *Cyatheites arborescens*, Brongn.; *Alethopteris gigas*, Gutb., *Tæniopteris abnormis*, Gutb., and *Walchia pyriformis*, Schlth. These sandstones are unconformably overlain by a thick deposit of red sandstones, probably the Bunter or Lower Triassic Sandstones. The Muschelkalk is met with in the same locality. The fossils are: Teeth of *Saurichthys*, *Lima striata*, Schlth., *Pecten discites*, Schlth., *Pecten Alberti*, Goldf., *Ostrea decemcostata*, Mstr., *Retzia trigonella*, Schlth., *Spiriferina fragilis*, Schlth., *Waldheimia vulgaris*, Schlth., and *Entrochites* in abundance. The overlying strata are white sandstones of unascertained age, and white Upper Jurassic limestones with hornstone and *Belemnites*. These limestones occur likewise beneath the Nerinæa-limestones of the isolated hill of Rabis. The Jurassics are conspicuously represented south of Belogradez by hard sandstones ("Middle Dogger"), with *Pecten demissus*, Phil.. *Monotis elegans*, Goldf., and *Belemnites* (near *canaliculatus*, Schlth.), conformably overlain by fossiliferous, distinctly stratified limestones, containing *Sphenodus macer*, Quenst., *Lepidotus maximus*, A. Wagn., *Aspidoceras orthoceras*, d'Orb., *Perisphinctes polyplocus*, Rein., *Simoceras Doublieri*, d'Orb., *Oppelia Holbeini*, Opp., *Oppelia compsa*, Opp., *Phylloceras tortisulcatum*, d'Orb., *Aptychus latus*, Park., *Apt. Bulgaricus*, sp. nova. *Rhynchonella Agassizi*, Zschn., and *Rhynch.* sp. (near *sparsicosta*, Quenst.).

Cretaceous marls with small *Belemnites* and *Inocerami* are found to a limited extent between Vrbova and Quprén. Middle and Lower

Cretaceous deposits prevail in the southern portion of the chain. The older sediments are represented there only by Palæozoic conglomerates and schists, and by the red sandstones near Berilovce, overlain by limestones and marls with *Orbitulina lenticularis*, two other species of the same genus, *Spongia Vola*, Mich., and other *Spongiæ*, one *Craticularia*, one *Sporadiscina*, some Corals and Polyzoa, and fragments of *Ostrea*, *Terebratulina*, *Terebrirostra*, and *Natica*.

Cretaceous sandstones rest on these beds; and beneath them, near Isvor, are fossiliferous, sandy, and locally somewhat oolitic Neocomian limestones, abounding with *Polyzoa* (among them a new species, *Heteropora Isovriana*), together with numerous joints of a *Pentacrinus* belonging to the series of *astralis*, Quenst., abundant spines of *Cidarites*, a *Peltastes* (near *stellulatus*, Ag.), and a new small Crustacean, *Prosopon inflatum*.

Friable Cretaceous sandstones then follow almost to the descent into the Nisova Valley, where Caprotina-limestones, resting on marls with *Pyrina pygmæa*, Ag., appear. Enormous deposits of rolled blocks and gravel cover the slope up to a considerable height.

REVIEWS.

I.—The Glacial Period in the Southern Hemisphere. By Thomas Belt, F.G.S. (Quart. Journ. of Science, July, 1877.)

IN all his former papers on the Glacial Period, the author has dealt mainly with phenomena connected with the glaciation of the northern hemisphere, a great part of which he has travelled over himself, and has therefore been able to bring his personal experience to bear upon the subject; but in treating of the southern, he is obliged to rely for his data on the observations of other geologists. This compilation of the recorded facts that relate to the subject-matter is undertaken, Mr. Belt says, with the view of refuting the idea which seems of late to have arisen in the minds of some geologists, that there is no evidence of a glacial period south of the equator; and to show that the phenomena there found agree with those of the northern hemisphere.

The first authority cited is Prof. Agassiz, whose theories concerning the Amazon valley are considered by the author to be mistaken ones. The Pampean mud, it is argued, owes its origin to the same causes as the loess of Central Europe and the silt of the Siberian steppes, viz. the formation of a freshwater lake through the damming back of the drainage by the advance of the south polar ice up the basin of the South Atlantic; and a similar explanation is hinted at for the plains of gravel and silt in New Zealand.

The icy barriers to these lakes would themselves be melting and so contribute to their formation, and there would, it is maintained, be no more reason for the lakes they caused being frozen than that the Manjalen Sea, which is formed in a similar way, should be so.

This advance of the ice in both hemispheres simultaneously towards the equator would result not from a flow of the ice in that direction, but from ridges being formed which intercepted the moisture travelling to the poles, and compelling precipitation to take place on the slopes nearest the equator, and thus, by continual accumulation, would these mountains of ice creep far into the temperate zones; whilst at the poles themselves there would probably be less ice than is found there at the present day.

This wholesale accumulation of ice at the poles, of course, implies a like abstraction of water from the sea, and Mr. Belt calculates that a lowering of the sea-level to the extent of 2000 feet took place all over the world.

The author agrees entirely with Prof. Tyndall, that to reduce the force of the sun's rays would cut the glaciers off at their source, and that "we cannot afford to lose an iota of solar action; we need, if anything, more vapour, but we need a condenser so powerful that this vapour, instead of falling in liquid showers to the earth, shall be so far reduced in temperature as to descend in snow."[1] This condenser, Mr. Belt maintains, exists within the Antarctic circle, which, as it moved northward, intercepted the vapour to be condensed in increased quantities.

As now-a-days polar ice is kept within proper bounds by the counterbalancing forces of nature (as Mr. Belt admits, p. 23), it must be left for physicists to decide on the causes that led to its extraördinary behaviour during the so-called "Glacial Period."

B. B. W.

II.—A SKETCH OF THE GEOLOGY OF LEICESTERSHIRE AND RUTLAND.

By W. J. HARRISON, F.G.S. Reprinted from White's History, Gazetteer, and Directory of the Counties. Large 8vo. pp. 67. (Sheffield, 1877.)

SKETCHES of the Geology of our English counties are always welcome. The residents who have any taste for the science naturally take especial interest in the geology of their own county, and to many of them, as well as to the occasional visitor, a work in which the principal facts are narrated is a great boon, because many have neither time, inclination, nor opportunity to study the numerous special papers that may have been written upon the subject.

Mr. Harrison has already done much useful work in this way by preparing a series of Outlines of the Geology of the Counties of England, many of which have appeared in Kelly's Post-Office Directories for 1876 and 1877. And he has now given us a far more elaborate sketch of the Geology of Leicestershire, accompanied by a short account of Rutland, which counties, from his position as Curator of the Town Museum at Leicester, he has had ample opportunity of investigating.

Leicestershire, geologically speaking, is one of our most interesting counties. In it we are brought face to face with some of the grander problems of Geology, as offered for solution in its tiny mountain-group of Charnwood Forest, where some of the older rocks are developed, and where the phenomena of igneous and metamorphic action may be well studied. We may add that here, too, we have abundant material for controversy. In the Lower Oolites, the Lias, and in the New Red Sandstone series, we may seek relief from the puzzles of the older rocks, while the complex history of the Drift deposits furnishes another pleasant subject of dispute.

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[1] Heat as a Mode of Motion, p. 188.

Commencing with the Crystalline and Slaty rocks of Charnwood Forest, Mr. Harrison notices their general structure and arrangement, describing in detail the principal sections. The granite quarries of Mount Sorrel and the syenite quarries of Croft, Huncote, Sopewell, Markfield, and Enderby, as well as the quarry at Bardon Hill, are represented in photographic plates. The stone of Bardon Hill is described by the Rev. T. G. Bonney as a felstone.

The coarse ashy slates of Broombrigg's Hill are likewise well shown in a photograph, and this neighbourhood is stated to contain the most typical outcrops of the slates.

Concerning the age of the old rocks of Charnwood, Mr. Harrison observes that they "may be put down as Lower Silurian [=Upper Cambrian of Sedgwick] with certainly as great a degree of probability as the theory has which assigns them to Cambrian [=Lower Cambrian] Laurentian age."

Many points of interest are furnished by the Carboniferous rocks, and especially in the structure of the Coal-district. No Coal-measures are exposed on the eastern flanks of the Palæozöic rocks, "the old elevation line of Charnwood seems to have bent southwards, and passing by Enderby and Sapcote forms a terminal ridge in that direction." But Mr. Harrison briefly discusses the probability of finding coal beyond this ridge, in the most easterly portion of Leicestershire.

In describing the Permian and Triassic rocks, allusion is made to the unconformity between the former rocks and the Coal-measures, and it is likewise pointed out that the Permian and Triassic rocks are unconformable, although "there are no good sections in Leicestershire to show this." It is only right to observe that the marked break between Permian and Trias which was formerly supposed to exist, is now questioned; while the overlap of the Trias merely indicates submergence and in itself affords no evidence whatever of unconformity. It may be questioned, too, whether the marks of erosion between the Bunter and Keuper are more than local, and such as we might expect to occur anywhere in such false-bedded accumulations.

Interesting accounts of the Rhætic beds, Lias and Oolites, and of the various gravels and other Dritt deposits, follow; there are some notices of remarkable boulders, and a plate showing glaciated and waterworn rocks at the granite quarry of Mount Sorrel. Notices of prehistoric man, of mineral springs, list of heights, glossary of technical terms, and records of colliery shafts, complete the subject-matter of the Geology of Leicestershire.

Rutland, until very recently, says Mr. Harrison, was quite a neglected county, so far as its geology was concerned, but since 1867 the researches of Prof. J. W. Judd, which have been published by the Geological Survey in the shape of map and memoir, have pretty well exhausted the subject.

Mr. Harrison describes the Liassic and Oolitic rocks, and the Post-Tertiary gravels and clays, noting all the economic features and other points of interest.

We should have mentioned that in describing the Geology of Leicestershire, due acknowledgment was made of the observations of other geologists—of Mammatt, Jukes, Potter, the Rev. W. H. Coleman, Hull, Ansted, and others. And we may add that the photographic illustrations, which to the number of twelve are scattered through the volume, are well executed, and represent, as clearly as photographs can, some of the grandest facts in the geology, which have been so carefully described and arranged in the letterpress by Mr. Harrison. H. B. W.

III.—LYMAN'S GEOLOGICAL SURVEY OF JAPAN.[1]

IT is now nearly three years since we noticed in Dec. II. Vol. I. of the GEOL. MAG. the preliminary report on the first season's work of the Geological Survey in the Island of Yesso. We have now before us four extremely detailed reports, making up over 900 pages of letterpress, with numerous maps, said to have an area of 190 square feet: the whole recording the operations of the Survey down to the year 1876.

Mr. Lyman does not appear to have allowed the grass to grow under his feet; and with the characteristic energy of our American cousins, we find that sickness was not permitted to arrest his progress, though the cure adopted was starvation; also, when thrown from his horse and seriously injured, he had himself carried, thus performing long journeys.

It speaks well for the capabilities of Japan that he has been able, within so short a time, to train native assistants, with the aid of but one fellow-countryman (Mr. Munroe), not alone in geology, but in surveying and mapping, so as to produce the very highly creditable results before us.

The printing of the reports is most excellent, clear and neat, the paper white and good, and though they have only stiff paper covers, they have a tasteful and business-like look, most having an index, and all possess the great advantage of clean cut edges. The maps, too, are well lithographed and photographed, faithfully reflecting Mr. Lyman's own style. They look perhaps rather crowded, but it is from the effort to make them contain all the information possible, in both Japanese and English writing, the latter in somewhat large thin block character, probably the most easily acquired by native draughtsmen. They have also contour lines to show the form of the ground, and what seem to be rather speculative lines to mark, not merely the outcrops of the important beds, but also their positions at various depths beneath the surface. One of the maps, a sketch of the geology of Yesso, is lithographed in colours, the first attempt of the kind made in Japan, its registry is almost perfect, and it could scarcely have been better executed anywhere else. On the whole there is no Geological Survey with which we are acquainted that produces its results in much better form.

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[1] Reports of Progress of the Geological Survey of Yesso or Hokkaido and the Oil-fields of Japan, the Island of Yesso, etc., 1874 to 1877, by Benjamin Smith Lyman, Chief Geologist and Mining Engineer. Tokei: published by the Kaitakushi (Colonization Board).

In some respects the reports may be called exhaustive, they are so numerous and so detailed. One section is given through 6500 feet of rocks, showing frequently the thickness of strata only amounting to small decimals of a foot, and the distances of one observation from another are often mentioned in the number of paces actually stepped, besides stating larger measurements and those of quantity in both English and Japanese terms. The angles and directions of dips and strikes are profusely recorded, and even the forms of the ground below the sea are mentioned.

Nor are the geology and economic geology alone the subjects of these reports; most of them have the form of a traveller's journal, abounding with remarks upon the topography, forests, water power, hotels, horses, weather, inhabitants, the customs, schools, spelling and pronunciation of Japanese names, political economy, in short nearly everything a tourist in a strange land would observe. Throughout, though geological features receive attention largely, the practical mining engineer as an observing medium is very evident.

Considerable space is devoted to Coal-fields, as a matter of course, the carriage and shipment of the mineral, with numerous tables, showing the constitution of the various beds, and we learn that there are in Yesso, both above and below sea-level down to 4000 feet, 150,000,000,000 tons of workable coal, or "two-thirds as much as the coal of the same thickness of the famous fields of Great Britain." One descriptive term of frequent occurrence, "bony coal," may be an American expression, with the meaning of which we are unacquainted.

The mineral oil of Yesso is black, thick, and does not seem to be of much economic importance. The island contains an estimated quantity of 3700 tons of native sulphur. One of the sources of this, on a promontory at the N.E. side of the island, is thus described: "It is a large hole in the midst of the deposit, . . . perhaps a hundred feet in diameter, and thirty feet deep, and at the bottom has a smaller hole, perhaps twenty feet long and fifteen wide. The smaller hole is full to within perhaps five feet of its brim, with a dark brownish-gray, muddy-looking liquid, which is boiling violently and spouting upwards for several feet in great commotion, and sending out heavy fumes of sulphur that hide the view much of the time. The liquid would appear to be nothing but melted sulphur; in the whole branch valley there was no water to be seen. Moreover, water could not exist at that temperature in such a place without quickly turning to steam and disappearing; and no steam is noticeable in the fumes. They are rising from the hole, are blown sometimes one way, and sometimes another, and have dropped powdery sulphur all about within a space of somewhat rectangular shape, about 250 yards long from top to bottom, and 150 yards wide across the valley, which here is broad and shallow, and slopes steeply westward, falling about 325 feet from top to bottom of the sulphur. There are no plants here, and the ground is covered with rough blocks of stone of one foot, two feet, or even six feet or more in diameter, a grey volcanic rock, trachytic porphyry containing sanadine. Among these stones the sulphur has gathered to irregular depths, in some hollows quite covering the stones like a snow-drift. In some places the sulphur is burning quietly at a depth of a few inches below its surface, and sending out fumes by small holes. Further down hill the sulphur has been washed by the rains down the bed of the stream now dry, and has collected into a solid pretty pure mass, a foot or two, or even three, in thickness, but only a few feet wide, though perhaps a hundred yards long." As would not be unlikely, there is no drinkable water within a mile and a half; the carriage to the shore is difficult; and yet it is thought a small profit might be made by working the deposit; the experiment of dipping up the molten sulphur is suggested, but no mention is made of any possibility of condensing and thus economising the fumes so largely given off.

Iron seems only to occur in the forms of magnetic iron sand along the shores of Volcano Bay, etc., and as bog iron ore in other places, the whole amount present being hardly more than 100,000 tons.

With regard to geology proper, extended knowledge of the ground has reduced the number of formations into which the rocks had been previously divided, so that, instead of the list formerly given, we have now the following:—

New Alluvium, perhaps up to	100	feet in thickness
Old Alluvium ,, ...	100	,, ,,
New Volcanic Rocks ,, ...	200	,, ,,
Toshibets Group, probably about	3900	,, ,,
Old Volcanic Rocks, perhaps	3000	,, ,,
Horumui (or Brown Coal-bearing) *Group*, probably about	6500	,, ,,
Kamaikotan (*Metamorphic*), perhaps	3000	,, ,,

The thicknesses, except those of the Toshibets and Horumui groups, are not based on any measurements, but inferred from general observations.

Mr. Lyman has seen reason to abandon the *Toshibets Kuril* division, and to include it with the *Toshibets Karafto* groups.

In one of his reports specially geological he has not adopted the chronological order of description, but inverted it, sacrificing the advantage derivable from giving a comprehensive idea of consecutive geological events.

A great want is that of geological sections showing the structure of the island, and the manner in which the different groups succeed each other. Sections across the coal-beds are frequently given, showing synclinal and anticlinal curves, the forms of which need not as a general rule be necessarily those assumed for them from observations on the dips taken at the surface, but we do not find a single section showing the geological relations of the formations, and this is the more strange because it would appear that ample materials for rough ones at least have been collected.

In connexion with his rock groups, our author, too, seems to place more importance than necessary upon the directions in which the beds are folded, the folds of different regions, or of the same region with different axial directions, being thought to mark different periods of disturbance, without the collateral testimony of unconformity or distinct superposition, or much other conclusive evidence being adduced to prove difference of age, either of the rocks themselves, or in their systems of disturbance.

The oldest group of the Island of Yesso is the *Kamaikotan* (or Home of the Gods) subdivision, a series of metamorphic quartzites, talcose and quartzose schists, blue marble, and blackish serpentine, with greenish impure limestone, granites, and mica schist. So far as we have gathered, these rocks are all distinctly stratified, they contain no fossils, and are sharply contorted with steep angles of dip from 45° to 60° or more. They form the core of the island, and any mineral veins they contain traverse also rocks of the next newer stage, so that it is doubtful if they contain any peculiar to themselves—even the gold of the superficial deposits not being excepted. These metamorphic rocks are of unknown age.

Next newer than this is the *Horumui* group, containing very numerous, but for the most part thin or impure beds of coal, with some good coal, having but a small per-centage of ash, and some 'furnishing' coke of good appearance. The rocks are chiefly sandstones of greenish or grey colour and grey shales or clays. The fossils found have been few, and not carefully studied; but the rocks are thought to be of early Tertiary or possibly of late Secondary age. In probably the lowest beds a *Ptychoceras* and some *Ammonites* have been obtained. This group is more than double the thickness of any other.

Conformably succeeding these, apparently, though this is not distinctly stated to be the case, is a group of *Old Volcanic* rocks, trachyte porphyries, with small crystals of glassy felspar, taken to be of late date, because of their rhyolitic character. Light grey, coarse-grained syenite occurs in them at several places, and diorite less frequently. These rocks, it is supposed, may have partly issued from volcanos that still send out new volcanic rocks.

Then comes the *Toshibets* group. possibly locally conformable and passing into that preceding. In this group Mr. Munroe distinguished two divisions, the upper of clays, sandstones and pumice, or other conglomerates derived wholly from volcanic rocks, and the lower of shales, sandstones and conglomerates. Between the two he thought at one place he detected an unconformity, though there was none elsewhere.

Derived pebbles of syenite and other crystalline rocks in these beds, supposed to have come from the *Old Volcanic* group, would at least suggest more of unconformity than is stated to exist.

One bed, 500 feet or so from the top of the group, contains fossil

Pectens, Oysters, etc., of very recent appearance, in considerable numbers. It is this group also which contains the slightly oil-bearing beds; the rocks are extremely disturbed, and are conjectured by Mr. Lyman to be of middle Tertiary age.

The *New Volcanic* rocks include those surrounding or near all the numerous volcanic mountains of the island—pumice of light-brown colour with capillary pores, trachytic rock, etc.; some of these volcanos still sending forth sulphurous smoke, and one having been in eruption as late as 1874.

The *Old Alluvium* consists of materials brought down by ancient rivers, just as the *New Alluvium* does of that now being deposited by the present streams. Overlying the latter are extensive marshes and some peat.

Among the minerals of less importance than those previously mentioned, the gold-fields of the island are, perhaps, only worth noticing, to say that, after close examination, the industrial prospects connected with them are unpromising, 180,000 dollars worth being barely workable.

The Survey is conducted under the orders of the Colonization Board, or *Kaitakushi*, whose multifarious supervision seems to include the making of roads, railways, bridges, building of schools, ownership of all the horses in the island, introduction of cattle, grain, and other plants from abroad, as well as fruit trees, the produce of hundreds of thousands, which will, Mr. Lyman observes, bring the good fame of the Kaitakushi most agreeably into everybody's mouth.

Although these reports leave the impression that there is a good deal still to be done in the way of elucidating the geology of Yesso, they contain a fund of interesting information, which warrants the wish of still further success to the Geological Survey of Japan.—W.

CORRESPONDENCE.

OSTRACODA AND FORAMINIFERA IN THE MIOCENE OF SOUTH AUSTRALIA.[1]

Sir,—In the Geological Magazine for July, 1876, Mr. Robert Etheridge, jun., has furnished a list of Foraminifera and Ostracoda derived from the matrix of mollusca obtained from the Government Well sunk on the Murray Flats, between the Burra and the North-West Bend, South Australia, and I wish to correct errors that he has fallen into in assigning the beds yielding the fossils to the post-Tertiary, and in remarking that the River Murray Flats must be composed of strata, geologically speaking, of no great antiquity.

The River Murray Plain is constituted of Miocene strata (contemporaneous with the fossiliferous beds of Tertiary age in the southern and western parts of Victoria, with which your correspondent is so familiar). These Miocene beds are bounded on the west by the

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[1] This letter has been by an oversight accidentally held over.—Edit. Geol. Mag.

Adelaide chain of metamorphic and slate rocks, where they are covered up by a Pliocene drift (of pluvial or glacial origin), containing remains of extinct marsupialia and trees only.

The two sets of deposits are shown in the Well-section alluded to, which is as follows:—

	Estimated thicknesses. Feet.
PLIOCENE—	
"Mallee" clay	40
MIOCENE (marine).	
Light-coloured sandstone with casts of shells	10
Gravelly ironstone and bands of clay Blue marl	81
Sandstone without shells	17
Loose sand	6
Actual depth	154

UNIVERSITY OF ADELAIDE,
June 18th, 1877.

RALPH TATE.

ELEPHAS MERIDIONALIS IN DORSET.

SIR,—At a recent visit to the Blackmore Museum at Salisbury, I was surprised to see two specimens of the teeth of *Elephas meridionalis*, which were labelled as found at Dewlish, in Dorsetshire. This being a preglacial species, it would be interesting to learn under what conditions they occurred at that locality, which is situated among the Chalk downs. The specimens were white, and had the appearance of having come out of Chalk debris.

The only specimen I have seen from any English locality besides the Cromer Forest-bed was a fragment at the Chichester Museum, said to have been found on the neighbouring Sussex coast.

Can any of your correspondents give information about these specimens?

O. FISHER.

REVERSED FAULTS IN BEDDED SLATES.

SIR,—I should like to call Mr. Hebert's attention to a few points in his article on the above subject in the October Number, which appear to require further consideration. Though it may be the established rule in some coal-mining districts that the hade of a fault is to the downthrow, there are in other districts exceptions to this rule, in which the faults are 'reversed,' or, as they are commonly called here, overlap faults. The cause of these reversed faults is, as stated, no doubt horizontal pressure, the results produced varying with the angle of hade, friction, and so forth. The causes of these horizontal pressures I should be glad to see further discussed by the author. The cooling of the earth, and consequent contraction of the nucleus beneath the solid crust, has, as well as the more local effects of earthquakes and volcanic intrusions, been suggested as a cause. It is evident that a local subsidence under an arched portion of strata will, if the abutments are stronger than the arch at the line of subsequent rupture (or fault), cause an overlap or reversed fault when the arch gives way, or it is evident that the matter may be complicated by a local upheaval of somewhat horizontal strata into a curve or arch; that then, while still upheaved and so distended laterally, a subsidence may take place towards the crown only of the arch, letting down the keystone, so to speak, as a 'trough' fault; then, on an extension of the same subsidence over a larger area, the arch, being keyed up afresh by the occurrence of the trough fault, can only give way by rupture of the nature of an overlap or reversed fault. These overlaps are sometimes on a considerable scale. Within a few miles of the place whence I write, there is a well-defined and proved and, as it happens, easily measured fault of this kind, in which the amount of movement is no less than 101 fathoms measured in the plane of the fault, the amount of throw being seventy-four fathoms vertical, and about sixty-nine fathoms horizontal. The hade of this fault is very nearly the same as Mr. Hebert's experimental ones, being 47°. I would also call attention to the fact that the *downward* vertical pressure P (*vide* his diagram) can in no case exceed the actual simple weight of the mass above the fault, and that in actual nature it is impossible (*vide* Fig. 2) for the left-hand portion to subside unless there be room for it to subside into. This room can, generally speaking, only be got by the horizontal *separation* of the masses on both sides of the portion subsiding. It would thus appear probable that all direct faults are of the nature of trough faults, that is to say, that either near or far off there is a somewhat parallel fault with an opposite hade, contemporaneous as to date of occurrence, and that this pair of faults meet sooner or later in depth. I would thus suggest that in the case of direct faults Mr. Hebert should in his inference substitute horizontal *tension* for vertical pressure (which is a secondary effect), and that the rule should be stated thus:—direct faults are indicative of horizontal tension, reversed faults of horizontal pressure.

STON EASTON, NEAR BATH. H. E. H.

PROF. MANTOVANI AND THE 'MIOLITHIC' PERIOD.

SIR,—Prof. Mantovani, in your last issue, proposes the term "Miolithic" for a period intermediate between the Palæolithic and the Neolithic. The term appears to be formed upon the "Miocene" of Lyell, which, of course, does not mean Middle Tertiary. Should the Italian Professor establish his new period, he would more appropriately substitute "Mesolithic" for "Miolithic." It is to be presumed he uses his terms in a purely local sense, for his Italian Miolithic age is represented as being contemporaneous with an age which produced "beautiful vessels of perfect work, resembling those of the ancient Etruscans," and was, therefore, probably post-lithic. The teachers of our science should not forget, for the sake of beginners, that the words "Palæolithic," "Neolithic," etc., represent, not absolute epochs of time, but stages in human development. CHARLES CALLAWAY.

WELLINGTON, SALOP,
Oct. 4th, 1877.

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ORIGINAL ARTICLES.

I.—ON THE OCCURRENCE OF CHALK IN THE NEW BRITAIN GROUP.

By Professor Liversidge, Etc., Etc.,
University of Sydney.

(Read before the Royal Society of New South Wales, July 4, 1877.)

IN the following brief notice it is my wish to communicate to the Society a description of the physical properties and chemical composition of one of the geological specimens recently brought from the above group of islands.

The specimen which I now have the honour to lay before you is not only interesting in itself, as an example of what is known as an organically formed rock, since it is built up almost entirely of the calcareous skeletal remains of organic forms; but it is interesting in a still higher degree, as it apparently indicates that a most important geological discovery has been made of the presence of chalk in a hitherto unknown, and even unsuspected, locality.

In October last, the Rev. G. Brown, Wesleyan missionary, brought amongst other specimens from New Britain and New Ireland (New Britain Group, latitude 4° S., and 150° E. longitude) certain grotesque figures of men and animals, which had been carved by the natives of the above islands out of a soft white somewhat pulverulent material, having much the appearance of plaster of paris or chalk. Some of these figures were deposited in the Museum, and a fragment broken off from one of them was placed in my hands for identification.

On examination the remains of numerous Foraminifera are at once detected, the forms of the larger ones being plainly visible, even to the unaided eye; under the microscope the whole mass of the rock is seen to be almost entirely composed of the shells and fragments of shells of Foraminifera, the remains of *Globigerinæ* being most abundant. To obtain the shells of the Foraminifera free from the cementing calcareous matter, it is only necessary to gently rub the surface of the specimen with a soft tooth or nail brush under a stream of water, when the whole surface of the fragment submitted to the operation speedily becomes studded with the minute shells and fragments of shells of Foraminifera, now left standing out in relief. To free the Foraminifera perfectly from the accompanying powder, it is sufficient to dry the collected debris and to place it upon the surface of some clean water contained in a glass beaker or other vessel; the larger or more cavernous Foraminifera float on the surface of the water, while the broken fragments, much of the amorphous powder, and many of the denser Foraminifera, are deposited at the bottom of the vessel as a sediment. The very light and finely divided parts are got rid of by decanting the milky supernatant liquid. In the sediment the microscope reveals the presence of the smaller Foraminifera, of a few sponge spicules, and minute grains of what are evidently siliceous and igneous rock.

The further examination showed that the material is limestone, having a very close resemblance to chalk, both in chemical composition and in physical properties; in colour it is not the dazzling white of some chalk, but bears a closer resemblance to the light grey varieties. Although it is essentially composed of carbonate of lime, still it is not perfectly pure; there are certain impurities present in the form of alumina, iron, silica, manganese, etc.; but reference will again be made to this question later on.

To ascertain whether my supposition that the rock might be regarded as chalk and not merely as a soft, white friable recent limestone, or as a deposit such as is now forming over parts of the beds of the Atlantic and Pacific Oceans, I took an early opportunity, when writing, to inclose a portion of the material to Mr. H. B. Brady, F.R.S., of Newcastle-on-Tyne, who has devoted himself to the study of Foraminiferous deposits, and I have since received a reply from him, in which he says:—

"First, let me speak of your chalk from the New Britain Group. I suppose you have ascertained that it is a Cretaceous chalk and not a friable Tertiary limestone. All the Foraminifera, or nearly so, are South Pacific recent pelagic and deep-sea species, *Globigerina bulloides*, *Gl. inflata*, *Pulvinulina Menardii* (a thick variety which I do not think is yet named), *P. Micheliniana*, and probably *P. Karsteni*, *Pullenia sphæroides*, *Nonionina umbilicatula*, *Bulimina Buchiana*, fragments of *Dentalina*, *Uvigerina*, etc. Also a characteristic *Pulvinulina*, with thick shell and honeycombed surface, not yet described, of which I have quantities in the 'Challenger' material."

In answer to a question as to the locality and mode of occurrence of the material used for the carvings, the Rev. G. Brown wrote to me as follows:—"The chalk of which the figures are formed is, I am informed, only found on the beach after an earthquake, being cast up there in large pieces by the tidal wave. It is only found, as far as we know at present, in one district on the east side of New Ireland."

We have now to consider its chemical composition in somewhat closer detail, and to compare the results furnished by analysis with those yielded by specimens of typical or true chalk.

Chemical Composition of specimen from New Ireland.

Hygroscopic moisture, *i.e.* water driven off at 100° C. ...	1·202
Carbonic anhydride	35·337
Iron sesquioxide...	1·597
Alumina	3·131
Silica	7·933
Phosphoric acid	Minute trace
Manganese protoxide...	·623
Lime	45·278
Magnesia	·476
Potash...	·308
Soda	·260
Chlorine	·105
Combined water and undetermined	3·750
Specific gravity, 2·199 at 59° F.	100·000

The specific gravity was taken from a mass weighing about 78 grammes, which was allowed to soak in water for about one hour and a half, in fact until all air-bubbles ceased to be evolved; a small quantity of the block scaled off when immersed in the water—a correction for which had to be made.

The above figures show that in round numbers about 81 per cent. of the specimen consists of calcium carbonate; thus it is undoubtedly a far less pure limestone than the ordinary white chalk, as the following figures indicate.

Chemical Composition of Chalk.

A specimen of chalk, from near Gravesend, which was analysed by Mr. W. J. Ward, yielded the following results:—

Calcium carbonate	98·52
Magnesium carbonate	·29
Calcium sulphate	·14
Manganese binoxide	·04
Phosphoric acid	traces
Organic matter	—
Insoluble matter, chiefly silica	·65
	99·64

Mr. David Forbes, F.R.S., also examined some specimens of chalk, the analyses of which are here cited; the first analysis shows the composition of a piece of white chalk from Shoreham, in Sussex; and the second of a piece of grey chalk from Folkestone.

	White chalk.	Grey chalk.
Calcium carbonate	98·40	94·09
Magnesium carbonate	·08	·31
Phosphoric acid Alumina and loss	·42	trace
Sodium chloride	—	1·29
Water	—	·70
Insoluble rock débris	1·10	3·61
	100·00	100·00

(Vide "Geology of England and Wales," by H. B. Woodward, p. 239.)

Another sample of chalk obtained from a well at Driffield was found by Mr. T. Hodgson to have the following composition:—

Moisture	5·20
Calcium carbonate	93·30
Magnesium carbonate	·15
Iron sesquioxide and alumina	·20
Silica	1·15
	100·00

It is, however, far less impure than the "chalk mud" of the Atlantic, for the analysis quoted by Professor Sir Charles Wyville Thomson, F.R.S., in his "Depths of the Sea," p. 469, shows that the "chalk mud" contains merely some 60 per cent. of calcium carbonate, and with as much as from 20 to 30 per cent. of silica, and varying proportions of alumina, magnesia, iron, and other substances. The same author mentions that the typical chalk is free from silica, and so it would appear to be from the above-quoted analyses; but the "insoluble rock débris" mentioned by the late talented David Forbes, F.R.S., probably consisted largely of silica.

The only locality for chalk in the Pacific Islands to which I can find any reference occurs in Dana's work on "Corals and Coral Islands," see p. 308. But this even is not true chalk; it is merely a recent limestone derived from disintegrated corals, and which resembles chalk.

"The formation of chalk from coral is known to be exemplified at only one spot among the reefs of the Pacific.

"The coral mud often looks as if it might be a fit material for its production; moreover, when simply dried, it has much the appearance of chalk, a fact pointed out by Lieutenant Nelson in his memoir on the Bermudas (1834), and also by Mr. Darwin, and suggested to the author by the mud in the lagoon of Honden Island. Still this does not explain the origin of chalk, for, under all ordinary circumstances, this mud solidifies into compact limestone instead of chalk, a result which would be naturally expected. What condition then is necessary to vary the result, and set aside the ordinary process?

"The only locality for chalk among the reefs of the Pacific, referred to above, was not found on any of the coral islands, but in the elevated reef of Oahu, near Honolulu, of which reef it forms a constituent part. It is twenty or thirty feet in extent, and eight or ten feet deep.

"The rock could not be distinguished from much of the chalk of England; it is equally fine and even in its texture, as earthy in its fracture, and so soft as to be used on the blackboard in the native schools.

"Some imbedded shells look precisely like chalk fossils. It contained, according to Professor Silliman, 92·80 per cent. of carbonate of lime, 2·38 of carbonate of magnesia, besides some alumina, oxide of iron, silica, etc.

"The locality is situated on the shores, quite above high-tide level, near the foot of Diamond Hill. This hill is an extinct tufa cone, nearly 700 feet in height, rising from the water's edge, and in its origin it must have been partly submarine. It is one of the lateral cones of Eastern Oahu, and was thrown up at the time of an eruption through a fissure, the lava of which appears at the base. There was some coral on the shores when the eruption took place, as is evident from imbedded fragments in the tufa; but the reef containing the chalk appeared to have been subsequent in formation, and afforded no certain proof of any connexion between the fires of the mountain and the formation of the chalk.

"The fine earthy texture of the material is evidence that the deposit was not a subaerial sea-shore accumulation, since only sandstones and conglomerates, with rare instances of more compact rocks, are thus formed. Sand-rock making is the peculiar prerogative, the world over, of shores exposed to waves, or strong currents, either of marine or of fresh water. We should infer, therefore, that the accumulation was produced either in a confined area, into which the fine material from a beach may have been washed, or on the shore of a shallow quiet sea—in other words, under the same conditions nearly as are required to produce the calcareous mud of the coral island. But, although the agency of fire in the result cannot be proved, it is by no means improbable, from the position of the bed of chalk, that there may have been a hot spring at the spot occupied by it.

"That there were some peculiar circumstances distinguishing this from other parts of the reef, is evident.

"This, if a true conclusion, is to be taken, however, only as one method by which chalk may be made. For there is no reason to suppose that the chalk of the chalk formation has been subjected to heat. On the contrary, it is now well ascertained that it is of cold-water origin, even to its flints, and that it is made up largely of minute Foraminifera, the shells of Rhizopods.

"Professor Bailey found under his microscope no traces of Foraminifera, or of anything distinctly organic, in the chalk."

The entire absence of any remains of Foraminifera must, I venture to think, completely destroy any claim for the Oahu limestone to be regarded as chalk proper. Neither can the Atlantic ooze, rich though it be in coccoliths and the shells of Foraminifera, be regarded as chalk. It is true that it may in future geological ages fulfil Prof. Sir C. Wyville Thomson's prediction and become such, but even of that we cannot be certain. At present it is a soft calcareous mud, and a very impure one. When consolidated and converted into dry land, instead of forming a brilliant white chalk limestone, a hard compact argillaceous or siliceous slaty limestone may be the result. The true white chalk so familiar to Englishmen is found over an area extending from the southern part of Sweden to Bordeaux, a distance in round numbers of 850 miles, and again from the northern part of Ireland to the Crimea, *i.e.* about 1140 miles. I am, of course, referring to the extent merely of the soft white limestone known emphatically as chalk, not to the areas occupied by that great variety of rocks which are classed with the chalk, and which are collectively known as the rocks of the Chalk or Cretaceous period, from the fact that they contain certain fossils in common.

Rocks belonging to the Chalk or Cretaceous period have a very wide distribution, being found in Europe, Asia, Africa, America, and in Australia from Western Australia to Queensland, and New Zealand. It may, perhaps, be mentioned as an argument in favour of the probability of the New Ireland limestone being properly regarded as of Cretaceous age, that we have Cretaceous rocks in Queensland as far north as 11° S., and in New Guinea, still nearer to New Ireland, we have rocks which undoubtedly belong to the Mesozoic or Secondary period, for amongst the geological specimens brought by Signor D'Albertis from the Fly River, and submitted to me for examination, there were Belemnites, an Ammonite (this Ammonite bears a very close resemblance to a Liassic form), and other fossils, such as teeth of *Carcharodon* and shells of *Pecten*, all of which may or may not belong to the Cretaceous age. It would be by no means a startling thing to find that these Secondary beds had an extension to the New Britain group of islands, a distance of only a few hundred miles, which would comprise an area by no means equal to the extent of country occupied in Europe by the typical white chalk. It should, however, be mentioned that no true white chalk has yet been found either in Queensland or in New Guinea.

In conclusion, it may be stated that the principal reasons in favour of the rock being regarded as chalk are that physically it is almost indistinguishable from most typical specimens of that rock, and that it has had the same organic origin; the Foraminifera alone are not, unfortunately, sufficient to rigidly determine the geological age of the rock, because they are types which have been persistent from the Cretaceous period to the present time.

II.—SUPPLEMENTARY NOTE ON THE FORAMINIFERA OF THE CHALK (?) OF THE NEW BRITAIN GROUP.

By HENRY B. BRADY, F.R.S., ETC., ETC.

SINCE writing the letter quoted in the foregoing communication by my friend Prof. Liversidge, I have had the opportunity of examining a larger fragment of the calcareous rock to which it refers, and am thereby enabled to add somewhat, not merely to the list of Foraminifera which it contains, but also to the general conclusions to be drawn from it. The lithological characters of the rock are, as Prof. Liversidge has stated, precisely those of many specimens of white chalk, but it is seldom that a Cretaceous mineral is so entirely composed of the recognizable remains of microzoa, and it is still more rarely that a geological deposit occurs, for which so exact a counterpart in process of formation can be indicated. Under these circumstances some further remarks on the subject may not be without interest.

The following is a revised list of the Foraminifera, with notes appended concerning a few of the less generally understood species:

Spiroloculina celata, Costa.
Lagena marginata, Montagu.
——— *lævis*, Montagu.
——— *apiculata*, Reuss.
——— *aspera*, Reuss.
Dentalina brevis, d'Orbigny.
——— *communis*, d'Orbigny.
——— *obliquestriata*, Reuss.
Vaginulina legumen, Linné.
Uvigerina asperula, Czjzek.
Bulimina Buchiana, d'Orbigny.
Cassidulina crassa, d'Orbigny.
Gaudryina pupoides, d'Orbigny.
Pullenia sphæroides, d'Orbigny.
——— *compressiuscula*, Reuss.
Globigerina bulloides, d'Orbigny.
——— *inflata*, d'Orbigny.
——— *Dutertrei*, d'Orbigny.
——— *sacculifera*, nov.
——— (*Orbulina*) *universa*, d'Orbigny.
Sphæroidina bulloides, d'Orbigny.
——— *dehiscens*, Parker and Jones.
Pulvinulina Menardii, d'Orbigny.
——— ——— var. *tumida*, nov.
——— *pauperata*, Parker and Jones.
——— *favus*, nov.
Rotalia Soldanii, d'Orbigny.
Nonionina umbilicatula, Montagu.
——— *pompilioides*, Fichtel and Moll.

This category, though considerably extended, by no means exhausts the material, for it contains, in addition, certain species of *Planorbulina* and *Truncatulina*, which I have not as yet been able to identify, besides fragments of Nodosarians, and some other obscure organisms.

Spiroloculina celata, Costa.—This name is adopted in the absence of a better for a species not uncommon in deep-water dredgings, both from the Atlantic and the Pacific. The test is composed of a uniform very fine sand, without any basis of calcareous shell; the sutures are scarcely discernible on the exterior; the aperture small and obscure, sometimes apparently wanting. It differs from the

Quinqueloculina agglutinans of d'Orbigny both in shell-texture and in general contour. The late Professor Costa figures such a form (Paleont. del. Regno di Napoli, pt. 2, pl. 26, fig. 5), though in somewhat clumsy fashion, under the name above employed.

Lagena marginata.—Two or three pretty distinct forms are included under this specific name. The varieties of *L. marginata* have not as yet been sufficiently worked out.

Globigerina sacculifera, nov.—This is a somewhat important modification of the Globigerine type, and one that appears almost to have escaped attention hitherto. Dr. Carpenter figures a poor specimen ('Introduction,' pl. 12, fig. 11) under the name *Globigerina helicina*, d'Orb., but the figures in Soldani's 'Testaceographia,' on which d'Orbigny founded that species, pertain to a very different form, the name for which cannot be spared. Reserving details respecting the subordinate groups into which the genus may be divided for another opportunity, it will suffice to state here that the trivial name *sacculifera* has been applied to a set of *Globigerinæ*, in which the terminal chamber or chambers take an elongate, pouch-shaped and usually pointed contour, and always present at least one large aperture on the superior or spiral surface. Such forms are common and grow to considerable size, especially in deep water south of the Equator.

Pulvinulina Menardii, var. *tumida*, nov.—A thick, oblong modification of *P. Menardii*, d'Orb. The superior surface is subconical, the inferior strongly convex. There seems to be no satisfactory description or figure of this variety, though the dead shells are common, and of large size, in many deep-sea dredgings.

Pulvinulina favus, nov., is a somewhat remarkable species. When fully grown, the test is lenticular, and nearly symmetrically biconvex, and the surface, except around the aperture, which is oblique, and peripheral, is covered with a raised reticulate ornamentation. The spiral structure is entirely concealed by the exogenous honeycomb-like shelly deposit. Young specimens are relatively much thicker than adults, and have the margin blunt or rounded.

Comparing the Rhizopod fauna characterized by the species above enumerated with what we know of the accumulations at present going on at the sea-bottom in various parts of the globe, it is not difficult to indicate recent deposits at depths of 1400 fathoms and upwards in either the Atlantic or the Pacific having the same general characters in their organic constituents. There is, however, one species, *Pulvinulina favus*, which serves to limit the area of comparison. A cursory examination of the rough notes upon about a hundred and fifty soundings from the "Challenger" and "Porcupine" expeditions has only furnished six localities at which this form occurs, and these are all of them between Stations 271 and 302 of the "Challenger" series, that is, from just on the Equator in the middle of the Pacific, on a course direct south and then east, to a point off the South American coast, lat. 42° 43′ S., long. 82° 11′ W., the depths varying from 1375 faths. to 2435 faths. Upon closer comparison it is noticeable that the soundings obtained from this area also resemble the rock under examination in the comparative rarity of *Pulvinulina Micheliniana*, one of the commonest of Atlantic Foraminifera, and in the scarcity of the arenaceous types. But little care was taken, in the process of washing, to preserve the Radiolaria, but such as remain are of the same species as those of the line of dredgings alluded to.

In conclusion, it appears to me not too much to say that after disintegration and washing this "Chalk" from the New Britain Group could not possibly be distinguished by its organic remains from a washed Globigerina-ooze dredged in 1500 to 2500 fathoms in the South Pacific. The determination of the exact geological age is a matter for geologists; my observations have necessarily been limited to the physical characters and the organic constituents of the specimen placed in my hands by Prof. Liversidge, but it appears worth considering whether the rock may not be part of a *recent* sea-bottom which has been distributed by volcanic or other agency.

Such deposits may be very old chronologically speaking, and we know by dredging experience that they do often become very hard and compact even comparatively near the shore. Mr. Brown's letter, quoted above, provides us with the required disintegrating force.

III.—AMERICAN "SURFACE GEOLOGY," AND ITS RELATION TO BRITISH. WITH SOME REMARKS ON THE GLACIAL CONDITIONS IN BRITAIN, ESPECIALLY IN REFERENCE TO THE "GREAT ICE AGE" OF MR. JAMES GEIKIE.

By SEARLES V. WOOD, JUN., F.G.S.

(such, I suppose, as that which blocked out the sea from the lake-basin during the depression which gave rise to the marine clays of the Lower St. Lawrence), or by the cutting away of barriers of drift, or even, he adds, by the "warping of the earth's crust." It does not appear that any of these terraces, though possessing great constancy of level, present such visible regularity as the well-known roads of Glenroy; but if, as is the more probable, the shrinkage of the lake-basin was due to the removal of an ice-dam, their origin would seem to be identical with that to which the inclination of modern opinion refers these roads.

A very interesting feature in the geology of the lake region consists in the buried channels now filled with and concealed by Drift. Some of these form the waste weirs just referred to, but they occur also at various lower levels, even to levels beneath those of the existing lakes; so that if opened again great modifications would take place in the hydrographical conditions of the St. Lawrence basin; and indeed Prof. Newberry ventures to assert that buried channels of communication exist between Lake Erie and Lake Ontario. If such exist, then, of course, Niagara could by their opening be laid dry, and he dwells on the practical service to which the various buried channels might be turned for engineering purposes. He also insists on the soundness of the rock-basin erosion theory as applied to the entire valley of the St. Lawrence. This valley he describes as having been prior to the Glacial period, and when the elevation of that part of the North American continent was considerably greater than now, the valley of a river-system which flowed at much lower levels than at present; and which, instead of reaching the Atlantic as it now does by way of the Gulf of St. Lawrence, flowed between the Adirondack and Appalachian mountains, in the line of one of these buried channels, passing through the trough of the Hudson River, and emptying into the Atlantic about eighty miles south-east of New York. At this time, according to the Professor, that part of the St. Lawrence valley which is now formed by the basins of Lakes Michigan and Superior formed no part of the river-system to which they now belong, but part of a separate river-system emptying itself into the Mississippi, the Straits of Mackinau not being then opened; and it is to the erosive action of the glacier-ice, which during the Glacial period crept down from the Laurentian highlands of Canada, and filled these pre-existing valley systems, that he attributes their excavation and conversion into the one great basin which now receives so large a part of the drainage of North America, and is referred to under the name of the lake-basin, or basin of the St. Lawrence.

Assuming that my suggestions as to the period and mode of origin of the Ohio Eskers have some good foundation, I propose, subject to the qualifying observations applied to each case, to suggest certain synchronisms between the Glacial and post-Glacial phenomena of the St. Lawrence basin and those of Britain, according to the view of the English beds to which their study has led me.

As a preliminary, however, it may be well, for clearness sake, to recapitulate in their descending order, from the newest to the oldest, the deposits of the St. Lawrence basin, with such alterations in their relative ages as I have suggested, viz.:

The later part of the Lake Terraces (beds No. 4), and the Eskers and Kames of the Canadian Highlands.
The earlier part of the Lake Terraces (beds No. 4), and the Marine Clays.
The Yellow Clays with Gravel and Boulders (beds No. 3*a*), and possibly a part of the Marine Clays.
The Forest surface resting on the Erie Clay (bed No. 2).
The Erie Clay (bed No. 1) which commenced with the formation of Eskers and Kames on the Ohio water-parting (beds No. 3*b*).

Approaching then the examination in detail of the conditions under which we may seek to find grounds of synchronism between the American and English series, we have first the oldest members in the series of each country to examine; and therefore, but without suggesting any synchronism between them by so doing, I place them side by side, viz.:

ENGLISH.	ST. LAWRENCE BASIN.
The Lower Glacial Series. This series begins with a littoral and estuarine deposit of pebbly sands (the Bure Valley beds of myself, and Westleton Shingle of Prestwich), containing a molluscan fauna differing but little (chiefly in the introduction of *Tellina Balthica*) from the later (Chillesford) beds of the Crag. These sands are fossiliferous in places, and contain *Mya truncata* with valves united and siphonal extremities vertical just as they lived; and they pass up by	The Eskers and Kames of the Ohio water-parting, being the washed-out moraine of the first ice-sheet, due to its dissolution subaërially, when at its southernmost extension it termi-

its recession only. The ice which accompanied the accumulation of the Lower Glacial beds does not appear to have reached so far south as did that to which the chalky part of the Upper Glacial was due; but after this accumulation a material change took place, and extensive troughs were excavated through these beds, which were filled in by the Middle and Upper Glacial deposits.[1] These troughs, by their re-excavation, have in great measure originated the present valley-system of East Anglia, part of such re-excavation having been produced by the advance along them of tongues from the inland-ice during the formation of the chalky clay, as presently explained.

At the bottom of one of these filled-in troughs, which has not been re-excavated, lies the Kessingland freshwater formation with some arboreal remains and a root-penetrated surface, covered evenly by the Middle Glacial sand. Whether this formation is a deposit *in* the trough, and therefore of interglacial age, or whether it is a preglacial formation which the excavation of this trough through the Lower Glacial beds uncovered without destroying, is a question for the determination of which no sufficient data have yet been detected. If, however, this formation should prove to belong to the period of interglacial trough excavation, it would not *necessarily* indicate an amelioration of climate, because, according to Milner's Atlas, forests in Norway, and according to Von Wrangel's Map, forests in Siberia extend many degrees of latitude north of that parallel (61° N.) down to which glaciers give off bergs in South Greenland.

The glacier, the accretion and extension of which accompanied the accumulation of the Lower Glacial beds, was, I think, most probably that of the Vale of Pickering, to which I shall in the sequel have occasion to refer in connexion with the Purple clay. If this glacier deflected south-eastwards over the Chalk along the line marked by the Purple clay which caps the Chalk towards Flamborough Head, its direction would have been straight towards Cromer, around which town for several miles the great masses of *remanié* Chalk are imbedded in the Contorted Drift. From Flamborough southwards this glacier would have travelled exclusively over Chalk, and terminating at some point between Flamboro' and Cromer, where the water was deep enough to generate them, would have sent off bergs laden with masses of *remanié* Chalk, which, grounding near Cromer, buried them in the marine silt, and gave rise to the contortions which accompany these masses, and to which this Silt or Drift owes it name. The elevation of the Lower Glacial sea-bed over Norfolk and Suffolk, which put an end to the accumulation of the Contorted Drift, reduced, it is probable, this depth of water and put an end to the generation of bergs by the Pickering glacier, so that a new state of ice arrangement resulted. Whether the outflow of this glacier was checked by an elevation of the sea-bottom, or merely by the great accumulation of sediment to which it gave rise, such a change in relative levels of the places of least resistance would have caused, I conceive, the ice to seek a new direction, the result of which was that its main flow deflected more directly southwards from the Pennine Hills, and formed the large glacier sheet to which the Middle Glacial sands and the chalky portion of the Upper Glacial clay owe their origin, and of which the motion was partly out through the Humber gorge, but principally southwards over Lincolnshire.

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[1] See S. V. Wood, Jun., and F. W. Harmer, in Q.J.G.S., Feb. 1877, p. 74, and F. W. Harmer in same, p. 134.

Since thus the earliest deposits of the Glacial period in Britain belong to that part of it during which the ice was beginning to accumulate and during which it was extending, but had not reached its culmination; while according to Prof. Newberry the Erie clay belongs to that part of it during which it was receding, we can hardly suggest any parallelism in time between this clay and the English Lower Glacial beds, unless that part of the period which followed the elevation of the latter and the excavation of the troughs through them was accompanied by a general recession of the ice and amelioration of climate, as to which there does not appear at present to be any reliable evidence. On the whole, therefore, it seems to me most probable that none of the American beds, so far as they have yet been described, are quite so old as the Lower Glacial series of England; but that the oldest of them represent the period of recession from greatest ice extension under which the principal glacial formation of Britain, the Upper Glacial, was accumulated.

As, however, the object of the present attempt at synchronism is tentative only, I have thought it most convenient to place the oldest described formations of either country side by side, as the clearer way of presenting the subject for the consideration of geologists, and therefore in pursuing that course we get next:

ENGLAND.	ST. LAWRENCE BASIN.
The Middle Glacial sand and gravel. The Upper Glacial beginning with the Chalky clay of East Anglia, succeeding which comes the Purple clay of Holderness, and such of the clay of the North of England as is not of Hessle age, and terminating with the Moel Tryfaen and Lancashire high-level sands with marine mollusca.	The Forest surface and associated beds (No. 2), which rest on the Erie clay. The beds 3*a* of Ohio and part of the marine clays of the Lower St. Lawrence and Atlantic coasts.

If, as already suggested, there was no general recession of the ice and amelioration of climate after the formation of the Lower Glacial series of England, and that therefore the Erie clay and Eskers of the Ohio water-parting more probably represent the Upper Glacial of England, then the beds of the St. Lawrence basin which are above placed beside the Middle and Upper Glacial would, I conceive, belong to that period which we have been accustomed in England to call post-Glacial, and during which a minor glaciation, I consider, occurred; and I think that this pushing forward of the American beds in the synchronism will eventually be found to accord best ith the entire group of facts.

ıe Middle and Upper Glacial deposits of England appear to me ıve been formed during the culmination and recession of the ice , as in the case of the Kames of the Ohio water-parting and of Erie clay. During the accumulation of the Middle Glacial sand gravel formation, it is not clear how far the ice extended, use, by the action of the inland ice on the western side of the Eastern counties, after the elevation of the greater part of into land which accompanied the protrusion of glacier tongues their valleys, as presently explained, this formation on the ern sides of these counties seems to have been destroyed. The n of these sands and gravels, however, appears to have been due e washing out by submarine currents of the moraine extruded he land-ice lying somewhere west of the line marking this uction in Suffolk and Norfolk which is defined in the sequel;[1] this was both accompanied and followed by the lifting and ping through the agency of floating-ice of sheets of the unified moraine itself, because we find such moraine occasionally stratified in the sands and gravels, as well as very extensively ing a thick bed of Glacial clay over them.

uring the first formation of these sands and gravels, the eastern of England must have been submerged some 400 feet, because ind them (without any indication of disturbance having occurred he floor which supports them) ranging from the present sea- l nearly up to that altitude. Near the southern extremity of ial clay occurrence in Middlesex, these gravels range up to ıt 300 feet at Finchley, where they are covered by the morainic , and in Essex to 367 feet at Danbury, where they are not so red. Between these points the morainic clay of the Upper ial occupies for the most part lower ground, resting direct on the don clay, as though, after the deposit of the sands and gravels, their partial overspread by the morainic clay dropped upon them, ice had advanced and ploughed out the lower ground, which was wards covered by the moraine extruded.[2]

he distribution of the same sands and gravels and of the ainic clay over parts of the counties of Hertford, Bedford, kingham, Warwick, Oxford, and Leicester, where in some inces they attain elevations somewhat greater than at Danbury, loses analogous features; and seems to indicate that similar ll extensions and recessions of the ice when at its furthest limit place in that part of England also.

s the sands and gravels with marine mollusca reach in North es to an elevation considerably exceeding 1300 feet, and in cashire, on the west slope of the Pennine ridge, to elevations

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considerable spread of coarse rolled flint gravel in West Norfolk resembling n shot seems to have resulted from similar current action during the formation e Upper Glacial chalky clay, upon which in some instances it seems to rest.

The position of the beds thus referred to is shown in the Geological representa of Ordnance Sheets 1 and 2, which I made, and in the year 1866 placed in the ry of the Geological Society, with a manuscript memoir and sections in illusn of it. It is also shown in the map at p. 348 of Vol. III. Geol. Mag. 1866.

between 1100 and 1200 feet,[1] it is clear that either at this time or subsequently the submergence must have much increased northwards and westwards. As, however, the mollusca of the Middle Glacial sands presents so decidedly an older and more Crag-like facies, and even the Upper Glacial at Dimlington and Bridlington contains the Crag forms *Nucula Cobboldiæ* and *Tellina obliqua*, while the Moel Tryfaen and Lancashire beds contain none but forms still living in British seas, and one or two more that live in the Arctic Sea immediately north of the Shetlands, we can hardly escape the inference that either a submergence of the Pennine region and North Wales took place after the accumulation of the earliest portion of the Upper Glacial (the chalky clay), or else that during this accumulation those mountain regions were enveloped in ice which, until the gradual passing away of the glacial conditions removed it (and therefore after the chalky and purple clays had accumulated), prevented the access of the sea and the formation of marine beds.

The chalky Upper Glacial reaches in Lincolnshire (Ponton) to elevations somewhat exceeding 400 feet, and in Herts of 550 feet, and the glacier to which it was due, and whose submarine recession most of its accumulation in my view accompanied, descended over Lincolnshire, but could hardly have extended much to the west of the meridian which touches the westernmost boundary of that county; because nearly all the material which makes up this clay is derived from the beds of that county, from the Trias to the Chalk inclusive.[2] At its greatest extension it existed in the form of inland-ice partly below the sea-level, just as now occurs in the case of some of the inland-ice of Greenland and of parts of Spitzbergen, its eastern edge resting upon the high ground forming the westernmost parts of Norfolk, Suffolk, and Essex, its southern on the north border of Herts, and its western, as already defined. Within these limits, although here and there a few sporadic occurrences of gravel under the chalky clay may be detected, and which I refer to some very localized current action issuing from the ice in its retreat, the chalky clay rests directly on the older rocks; while on every side of it, except the north, where the glacier connected with the place of its genesis, the sands and gravels which I term Middle Glacial occur extensively, though not uniformly. On its west side this glacier probably terminated direct in the sea, but on its eastern side it was, as presently described, divided from the sea during part of the Upper Glacial period by a belt of land formed of the eastern parts of Essex, Suffolk, and Norfolk. To the action of this glacier, when, during its greatest extension, its principal mass rested on the great Fen level, do I attribute the formation of that level itself; its edges as above defined being on all sides, except the north, within twenty miles of the Fen boundary; and to the extrusion of its moraine during recession do I refer the principal part of the chalky clay, the rest having been accumulated by droppings in mass from ice which floated in the sea during its greatest extension, as well as in the sea that followed up its recession. As explained subsequently, a branch from this glacier passing through the gorge of the Humber carried out into Holderness nearly all the moraine engendered north of that gorge, as well that engendered for a few miles south of it, the ice against the Wold scarp drawing in from both sides of this gorge to form a tongue which issued through the valley of the Humber. Thus, as the glacier receded northwards, the moraine extruded became less and less, so that before it receded to the latitude of the Humber it had shrunk away from the Chalk Wold on its western side, and there was no more chalky moraine to extrude. North of Holderness, however, the glacier which came through the Vale of Pickering, and passed over the lower ranges of the Wold for a few miles inland of Flamborough, to which I have already adverted as giving off bergs during the accumulation of the Contorted Drift, but which, after the termination of that accumulation, ceased to give off bergs, and which also had wasted back under the influences which caused the Lincolnshire glacier to waste back and disappear, still brought chalk debris, derived from the north scarp of the Wold, but accompanied at first by a corresponding abundance of the hard rocks which lie north of the Wold, and form the opposite side of the Pickering trough.[1] This morainic material is of a dark purple colour in its lower part, changing to a more reddish purple upwards. In its lower part it is full of rolled chalk mixed with the more angular debris of hard rocks, and at its junction with the lead-coloured chalky clay at its base (*a* of the sections and map) sheets of it frequently alternate with sheets of the latter, showing, it seems to me, that from this horizon at least upwards the clay of Southern Holderness originated from the dropping process, and other forms of marine deposit, and not by direct moraine extrusion. As we see the succession upwards, exposed in the high cliff of Dimlington, and that south of Mappleton, where the uppermost part of the purple clay has escaped the denudation which, prior to the Hessle beds, destroyed it elsewhere to the south of Bridlington, the rapid decrease of the chalk debris is very marked, but the decrease of the debris of the hard rocks north of the Wold is much less conspicuous. Still, even this diminishes, and though it continues in the clay of the upper parts of these two cliffs, it becomes so scant that in the uppermost part where the chalk debris has wholly ceased, and where the Hessle clay with its subangular chalk debris wraps over it, there is very little debris of any kind in the clay. It is in fact a stiff mud, much resembling, save that it is stiffer and uncontorted, and has no chalky sediment intermixed in it, the Contorted Drift of Cromer Cliff, which is generally conceded to be a marine silt, though nearly destitute of organic remains. It is, I think, more than doubtful whether any of the clay without chalk south of the Pickering trough is of direct morainic origin, either as originally extruded, or as dropped. It seems to me, though produced from the grinding of the glacier-ice, to have been distributed by marine agency, accompanied by the dropping of erratics from floe-ice; for not only is this clay full, though at no particular horizon, of lenticular beds of sand (c' and d' of Section I.)—a feature which the true morainic chalky clay of East Anglia lacks—but it presents the most marked contrast to the small moraines of pure. rolled chalk ($\bar{c}$ of the same section) which underlie it, and occupy ravines or gullies in the chalk floor where it rises above the beach from Bridlington northwards. These small moraines are evidently connected with the purple clay containing much chalk of the cliffs south of Mappleton (*c* of the section), the place of which they occupy relatively to the clay with little and no chalk (*d*) that overlies both; and having been formed beneath the Pickering glacier while it still rested on the north-eastern extremity of the Wold after the termination of the chalky clay formation, they seem confirmatory of the mode in which the retreat of the ice took place, as indicated by the other phenomena previously discussed.

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[1] Darbyshire, Geol. Mag. 1865, Vol. II. p. 293.

[2] The Upper Glacial of Middlesex and Essex contains little other chalk than the hard form of that material characteristic of Yorkshire and Lincolnshire; but in Norfolk a good deal of soft chalk is intermingled, and in the case of the morainic clay in the valleys of that county produced, as mentioned further on, by glaciers protruding tongue-like from the great mass of inland-ice, the chalk debris seems mostly of the soft character of the valley floor on which it rests. The fact that the chalk so abundant in the Glacial clay of Middlesex and Essex is all of the hard kind (at least if any of the soft is present it is so occasional that it has escaped my notice), seems to me to go a long way in proof of this clay not being what Mr. Geikie makes it out to be,—the submoraine *in situ* of a glacier which reached to the Thames Valley; for if so the chalk debris would be that derived from the counties of Essex, Middlesex, Herts, Cambridge, Suffolk, and Norfolk exclusively, instead of, as it appears to be, chalk derived in chief part, if not exclusively, from Lincolnshire.

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[1] This trough is that lying between the north scarp of the Chalk Wold and the slope of the Eastern Moorlands formed mostly of rocky Jurassic beds. Its eastern end is now blocked up by the last of the morainic clay which its glacier engendered, so that the drainage flows in the opposite direction to that in which the moraine travelled to the sea, viz. westwards and round the north-west angle of the Wold, and thence southwards to the Humber, west of the Wold scarp. During the Contorted Drift the Pickering glacier, I conceive, travelled perhaps 50 miles on both its sides over chalk; but at the period of the commencement of the purple clay it had shrunk back so that one side only touched the chalk, and this for a few miles only, and as the purple clay deposit proceeded, it gradually shrank from the chalk altogether.

As this mud-like clay (*d*) caps the cliffs continuously northwards from Bridlington to the mouth of the Pickering trough (which it blocks up), and for several miles attains elevations between 350 and 400 feet, it seems to me to indicate that when the Pickering glacier by shrinking back gave rise to its accumulation, Yorkshire must have been submerged to that extent.

The recession of this glacier through the Vale of Pickering after the disappearance of the glacier which produced the chalky clay is thus, it seems to me, very clearly indicated; as well as two corollaries; the first of which is that, when the chalky clay was in progress of accumulation, the contemporaneous moraine that passed through the Vale of Pickering was left out in the sea beyond our present shores; and the second of which is that, since the further north the latitude the later must have been the recession, the Glacial clay of the northernmost English counties is later than all this of Holderness, except possibly that which, wholly destitute of

Chalk debris, immediately underlies the Hessle clay wrapper in the two high cliffs already mentioned; while that of Scotland, so far as it belongs to the same period of glaciation, is latest of all, and may have accumulated while the South of England was the theatre of the disturbances presently referred to. Moreover, when the latest part of the Upper Glacial formation, the Moel Tryfaen and Lancashire high-level sands, was accumulated, it is clear that, except to the extent possibly of some glaciers still remaining in the valleys of the islands to which the mountain district of the North of England was at that time reduced by submergence, there could have been no ice enveloping the Southern extremity of that district, though Snowdon and other higher mountains of North Wales may possibly still have been snow-clad. The North of Scotland, too, from its latitude, may also at this time have not been freed from its ice, so that the morainic clay of that part of Britain, except so far as it may be of later (*i.e.* Hessle) age, may even be synchronous with these high-level sands of Lancashire and Wales, for the shells which have occurred at Elie and elsewhere on its eastern coast, though more Arctic in character, possess the same modern facies as do those of Moel Tryfaen, and of Macclesfield, as well as those from gravels of Hessle age.

In the East of England the sea, during that earlier part of the Glacial period to which the Contorted Drift belongs, was evidently deep enough to buoy up the glacier which occupied some part of the Chalk country, and break off portions into bergs; and these, from the dimensions of the masses of reconstructed Chalk which by their grounding they introduced into the mud of that drift, must have been of considerable size. What that depth of water was it is difficult to estimate; but when we consider that the mass of Lower Glacial deposits in which these bergs grounded was itself in that part near 200 feet thick, it is clear that at this stage in the Glacial period the Eastern counties must have undergone, since the time of the newest Crag beds, great depression and submergence. As already mentioned, however, this sea-bed had, prior to the Middle Glacial sands, undergone denudation, the effect of which was to excavate along the lines of our present valleys wide and deep troughs, in which to a great extent these sands accumulated, and were overspread in their turn by a deposit of the morainic chalky clay. After this, as I shall presently endeavour to show, so much of this area as forms the eastern part of the counties of Norfolk and Suffolk was early in the formation of the chalky portion of the Upper Glacial converted into a belt of land, which divided the inland-ice from the sea, and through the valleys of which that ice in the form of glacier tongues escaped. By the well at Yarmouth, described by Mr. Prestwich in the 16th vol. of the Journ. of the Geol. Soc. of London (p. 450), we learn that the depth to which one of these valleys, the Yare, has been excavated and filled up since with silt and mud is 170 feet below Yarmouth, or about 155 below Ordnance datum. This is not only far below the surface of the adjoining sea-bottom, but is below the surface of that sea-bottom everywhere between Norfolk and the coast of Holland, except for a small space about midway, where the soundings range between twenty-five and twenty-eight fathoms; and it is possible that this remarkable excavation was accomplished by the glacier tongue which then passed through the Yare valley.

Probably the North Sea was deeper throughout the Glacial period than it now is, for it must have been greatly filled with silt since then, like the Yare valley at Yarmouth has been, as well as in parts of it been filled with deposits of Glacial age also;[1] and since then it has, as several things contribute to show, been in its southern part converted into land and again submerged. At the time, however, when the land-ice escaped through these valleys to the sea, even if we assume that the table-lands out of which these valleys are excavated did not stand so high above the sea-level as they now do, we can scarcely, in view of this depth of the valley at Yarmouth, assign a greater depth to the sea in which the eastern side of the inland-ice escaped than 200 feet,—a depth too small, I take it, to engender bergs.

Towards Belgium it seems to me that this sea continued to shoal, so that, although the South of England and the Boulonnais (and I suspect also a part of Brittany) were covered by it, the shore lay for the most part outside the present coast of Northern France, passing thence across Belgium, where the Rhine and other rivers during the summers of the Glacial period poured over the flats surrounding their embouchures the floods to which the deposits of *Limon Hesbayen* and *Limon des plateaux* were due.

The gravels which over the West of England represent in my view the Upper Glacial were cut through in excavating the Mickleton tunnel at the northern extremity of the Cotteswolds,[2] where they were found in great thickness at an elevation reaching to 490 feet, occupying what was evidently a channel or strait dividing the small island formed by Ebrington Hill from the main island formed by the Cotteswold range at that time. This gravel has been traced by Mr. Lucy up to elevations in the Cotteswold region between 600 and 700 feet; and it is evident that the washed-out moraine of the glacier which, descending over Lincolnshire, gave rise to the chalky clay, has contributed to the material of this gravel, because there occur in it the large coarse flints so characteristic of that clay, and also pieces of the red chalk, and much more of the hard white chalk of Lincolnshire and Yorkshire.[3]

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[1] I learn from M. E. Vandenbroek of Brussels that the Crag to a depth of 415 feet has been sunk through at Utrecht, in Holland, *under* 760 feet of (so-called) Quaternary accumulations, the boring at that depth (1175 feet) being still in sands whose fossils agree with the Coralline Crag, and not those of the earliest of the Belgian Crag-beds. This seems to me to show that the bed of the North Sea, undisturbed by the Scandinavian glacier-ice, has been tranquilly receiving sedimentary accumulations from the commencement of the Pliocene period up to the conversion of parts of it into land at the close of the Glacial period.

[2] See Gavey in Quart. Journ. Geol. Soc. vol. ix. p. 295, for full description of the Mickleton cutting; also Hull, in vol. xi. p. 477.

[3] "The Gravels of the Severn, Avon, and Evenlode, and their extension over the Cotteswold Hills," by W. C. Lucy, read April 7th, 1869, before the Cotteswold
, and printed separately.

In one part of the South of England, the gravels which in my view represent the Upper Glacial range also to elevations between 600 and 700 feet, as at Cæsar's Camp, near Aldershott, and other detached hill-summits N.N.W. of it, but elsewhere, as at Headon in the Isle of Wight,[1] at St. George's Down in the same island, at Chilworth Tower, Stony Crop, and Bramshaw Telegraph in Hampshire,[2] and at Swanscombe Hill in Kent, the limit of their elevation ranges from 300 to 420 feet. Such of these summit gravels as lie north of the Chalk district that divides the Hampshire from the London Basin may be all continued by numerous other gravel-topped eminences of less altitude across the counties of Berks, Buckingham, and Hertford in the one direction, and across the Thames Valley in another, into contiguity with the unwashed moraine which the chalky clay represents.

The elevation attained by the gravels in the Cotteswolds probably affords a measure of the extent of the submergence in that direction, as these are remote from the theatre of submarine disturbances which have so elevated the gravels of the South of England. From the description given by Mr. H. B. Woodward of the Devonshire gravels, this submergence does not appear to have diminished for a long distance further south-west. The elevation of the gravels over the South of England (Surrey, Hampshire, etc.), however, affords, in my view, no measure of the depth of the sea in that direction, because these gravels attain greater and greater elevations as they approach the points where the highly inclined position of the chalk shows the region to have undergone great elevation relatively to the rest of the gravel-sheet before so much of it was destroyed by the denudation resulting from the disturbances producing this exceptional elevation. A study of the position of these gravels in Hampshire, Surrey, Berks, and Kent has convinced me that the sea under which they accumulated was not deep; and that though it covered in a general sense the whole of the South of England, there were many islands over that part of Britain formed by such of the higher hills as had come into existence before the Glacial period, and were not, as were the Hogsback ridge and the Purbeck and Wight anticlinals, produced by the disturbances of this period.[3] It

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[1] Geol. Survey Memoir on the Isle of Wight.

[2] Codrington, Quart. Journ. Geol. Soc. vol. xxvi. p. 528.

[3] I have in various papers during twelve years past, and particularly in one on the Weald Valley denudation in Quart. Journ. Geol. Soc. for 1871, urged that the disturbances in which the rectilinear upcasts of the Isles of Wight and Purbeck, as well as those of the Hogsback and Portsdown Hills, originated, took place at this time; viz. the close of the Glacial period and beginning of what we in England have been accustomed to call the post-Glacial; and it is interesting to me to find that Mr. Prestwich, in a paper read in the year 1874 (Q. J. G. S. vol. xxxi. p. 29), makes out that during the Glacial period that portion of the Purbeck and Wight anticlinal which is continued north of Portland Isle was submerged, and then upheaved and subjected to excessive deundation, though he does not admit the general submergence of the South of England.

The section given in the Geological Survey Memoir of the Isle of Wight through Headon Hill, with that in the Memoir on the London Basin through Cæsar's Camp (vol. iv. p. 376), are, it seems to me, not reconcilable with anything less than this general submergence; and show to my mind clearly the excessive denudation which was, I contend, with disturbances of an intense character taking place under the sea at this period that the emergence of the South of England commenced, and it was to the long train of changes which thus beginning continued through the period of minor glaciation that we have hitherto called post-Glacial, and which I have endeavoured to trace in my paper on the Wealden Denudation in the Journal of the Geological Society for 1871, that in my view the South of England, including the Wealden Valley, was brought to its present form and condition.

In reference to the elevation of the greater part of the East Anglian counties into a belt of land early in the progress of the formation of the chalky clay, there exist certain phenomena connected with the valleys of that district which have long been a subject of perplexity to me, and in reference to which the following passage occurs in the recent paper by myself and Mr. Harmer, "On the later Tertiary Geology of East Anglia," already quoted, viz.: "It is also a perplexing feature that some denudation has occurred at the bottom of valleys by which the Upper Glacial (or clay undistinguishable from it) rests directly on beds older than the Middle Glacial sand, as is shown in Section XV. [of that paper] in the case of the Ket Valley, and of which instances are also to be found in the Waveney, Blyth, and Gipping Valleys. This, if the clay so occurring be the Upper Glacial, seems to have taken place either during the accumulation of that deposit or that of the Middle Glacial, but to have been very partial or local."

The explanation of the difficulty has since occurred to me; and it is, as already mentioned in these pages, that after the Middle Glacial had been deposited and received by dropping a covering of morainic clay, the area of the Eastern counties intersected by these valleys was converted into land which formed a belt dividing the land-ice from the sea, as is the case at the present time in Central and South Greenland; and that through the valleys traversing this belt, or some of them, the land-ice issued in narrow tongue-like glaciers to the sea, as it does in those parts of Greenland at the present time. In Greenland this belt is formed of lofty land, but in East Anglia the belt must have been of land even lower than the present.

The section afforded by the cutting of the Cromer Branch Railway at Thorpe near Norwich, some years ago, though puzzling at the time,

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accompanied the acute upthrow of these rectilinear ridges, just as Mr. Prestwich shows it has done the portion of one of them which is continued through the Portland district.

The restoration map No. II. of the plate to the paper by myself on the Weald above quoted shows what I regard as the distribution of land and water at that particular stage of this emergence, when the oldest part of the gravel lying within the Thames Valley commenced to form and when the West and South of England were to a great extent still submerged.

I ought to add also that Mr. O. Fisher in 1868 (Geol. Mag. Vol. V. p. 99), suggested that the lofty gravels over the Southern counties represented the Upper Glacial. At that time I regarded them as somewhat later, and as having accumulated after the glacial clay had been removed from that part of England by denudation, but I have for several years past given up this view in favour of that of Mr. Fisher.

appears to me now to throw a clear light on this case. This cutting was made through the north side of the Yare Valley, and in it the chalky clay was exposed with the Middle Glacial sand containing its shell-bed under it on the upper part of the valley side; but lower down the whole of the clay had been ploughed out, and the sand was all twisted up with the Lower Glacial (Bure Valley) sand, on which, after the first excavation of the valley, it had been deposited. In the valley below the chalky clay may still be seen in section resting on the glaciated chalk floor of the valley, and it is clear that we have here an illustration of what glacier-ice produces when moving over clays and sands, viz. their destruction in part and the twisting of the rest with the soft beds on which they repose.[1] A similar feature of ice plough was afforded (some years ago when the cutting had been fresh scarped on one side) by the railway cutting at the East Suffolk Railway Junction, Ipswich, in the Gipping Valley. If such features were exhibited generally over the plateaux through which these valleys are cut, we might explain them merely by a general advance of the ice; but there has been no such ploughing over the plateaux, as the numerous inland pit sections over them and the continuous sections of them which the cliffs north and south of Lowestoft afford, show in the case of the Yare Valley most clearly.

Thus the succession of events in East Anglia was, first the deposit by marine agency over a floor formed of Chalk, Lower Tertiaries, and Crag, of the Lower Glacial series in considerable thickness; next the excavation of the valley-troughs (whether subaërially or subaqueously may be here left out of consideration), into which, as shown by Mr. Harmer and myself, the Middle Glacial sand was bedded and covered by the chalky clay; and then, while the chalky clay was still in progress, these deposits were elevated into land, so as to form the coast belt which I have described. This belt was pressed on its western side by the great body of ice which, having passed over Lincolnshire, occupied the fen, and from whose mass the tongue-like glaciers passing through some of these valleys to the sea went off and formed the means by which the land-ice escaped; and these by their ploughing produced that subsequent denudation of those valleys, and gave rise as they receded to those deposits of morainic clay which we find in them, resting upon glaciated chalk, which were so long puzzles to me. In the case of the smaller valleys as well, as in those lateral to the few main ones through which the glacier tongues passed, the patches of chalky clay which occur in their bottoms appear to have been produced by the drifting into them of floe-ice freighted with sheets of the morainic material. The action of this inland-ice upon the western parts of Norfolk and Suffolk may also be traced in the abrupt termination in these parts of the counties of the Lower and Middle Glacial, as though both had

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[1] Where this cutting was carried through, sand had rested on sand, viz. the Middle Glacial on the Bure Valley beds; but a pit about a quarter of a mile west, of old date, showed the Middle Glacial sand resting on the Contorted Drift, which in that neighbourhood is uncontorted. The valley plough referred to in the text had here contorted the two together, and so given rise to this exceptional feature.

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bed was accumulated prior to the excavation of the Waveney Valley, and when the chalky clay formed a continuous table-land across it, the gravels of the Waveney Valley associated with the bed being referred to a general system of high-level river-gravels over England and Northern France, which marked either the commencement of the excavation of the valleys of the rivers, or a period when that excavation was in progress, and when the rivers ran at a corresponding higher level. The late Mr. J. W. Flower opposed this view, insisting that the physical structure of the country around forbade the possibility of the Waveney River having been the agent by which the valley containing it has been excavated—a contention that assists, if it be necessary, the proof of what seems clear to me, viz. that the valley originated interglacially between the Contorted Drift and Middle Glacial, and was then subjected to re-excavation by one of the glacier tongues, which in its recession left behind it the deposits of chalky clay which occur at intervals on the sides and bottom from the mouth to the head of the valley. These deposits seem to me to furnish irrefragable proof that the valleys in which they occur had been excavated to at least their present depths before the chalky clay had ceased to accumulate; and, but for the physical conditions to which I have referred as having succeeded the formation and conversion into land of the earliest part of the chalky clay, they would present a very puzzling problem. The passage, however, of glacier tongues through some of these valleys (and amongst them that of the Waveney), by which the escape of the land-ice over the Fen took place, seems to me to remove the difficulty; because, by filling up the valley, these glacier-tongues would have given rise to physical conditions similar to what would have existed had the Waveney Valley not been excavated—conditions which have been deemed necessary to explain the position of the Hoxne brick-earth; for if we regard the lagoon in which the brick-earth accumulated as held up by the ice in the way in which glacier lakes are, then, as the glacier receded and the sea took its place at a lower level than the top of the ice, the water of the lagoon would escape, and in so doing denude that side of the brick-earth over which this escape took place, giving rise thereby to the Goldbrook Valley.

If I am right in this, the Hoxne bed, though necessarily posterior to so much of the chalky clay as crowns the table-land through which the valley runs, is yet anterior to the great mass of that clay which covers the Fen country and Lincolnshire, and about synchronous with such parts of it as occur in the valley bottoms of East Suffolk and Norfolk; and this would carry the evidences of man's occupation of Britain some way back into what I regard as the true Glacial period.

(*To be concluded in our next Number.*)

IV.—ON A NEW MARINE BED IN THE LOWER OOLITES OF EAST YORKSHIRE.

By GEORGE BARROW, F.G.S.;
of H. M. Geological Survey of England and Wales.

[By permission of the Director-General of the Geol. Surv. of the United Kingdom.]

ABOUT half-way between Hayburn Wyke and Cloughton Wyke, and five miles North of Scarborough, a scar of hard sandstone, remarkable for its even bedding, may be seen rising with a considerable dip from the sea. This sandstone contains along its bedding planes occasional thin layers of a very dense ironstone, from which it has probably received the name of "Iron Scar." Immediately beneath are about five feet of shales closely resembling those of the Middle Lias, and containing two bands of dogger ironstone.

A careful search shows that the uppermost of these two bands contains a few small fossils; while the base of the sandstone contains casts of *Nucula minima?* in great numbers.

This particular bed of sandstone would scarcely attract much attention, but for the fact of its constant presence in the great mass of false-bedded sandstones which wedge out in both directions in the face of the bold cliffs of this district. It can easily be traced from the above-mentioned locality to Blea Wyke and the great Peak fault, between which points it is seen about 160 feet above the Dogger, or top bed of the miners, and about 130 feet below the Millepore bed.

It is not seen again in the cliffs till we reach Hawsker, and it first comes to the face of the cliff immediately on the North of Maw Wyke, from which point it continues to High Whitby, and after turning inland for a short distance, once more reappears just North-west of Saltwich Nab. From this point it continues to the mouth of Whitby Harbour, where it is the capping rock of the East Cliff.

In all this long exposure, though the bed preserves the same lithological appearance, it contains very few fossils, and would have remained unnoticed perhaps, but for the fact of its far better development inland. At Whitby its only remarkable feature is the sudden development of a false-bedded conglomerate in the midst of the sandstone; a condition which can be well seen on ascending the Old Church Steps on the East Cliff.

Inland we have to go as far as Goathland on the Whitby and Pickering Railway, before seeing the typical section of what, in spite of its thinness, we believe to be an important marine bed in the great Estuarine series of East Yorkshire.

About 500 yards down the stream, Eller Beck (from which we propose to call it the Eller Beck bed), below Goathland, and a little below the picturesque village of Darnholm, is a small Force of about seven feet fall, the Force being caused by a close-grained very hard sandstone, well bedded and flaggy at the base, and passing insensibly into a shale, identical in appearance with the shales of the Ironstone series of the Middle Lias. The following is the section, in descending order, at this point, called Walk-mill Force, on the Six-inch Maps:

(*a*) Ten feet of Sandstone, hard and dense at top; flaggy at base.
(*b*) Four feet of shale, ferruginous and sandy in upper part, much resembling the shales of the Middle Lias Ironstone.
(*c*) Five inches of dense earthy ironstone.
(*d*) Five feet of shales, similar to (*b*).
(*e*) Fourteen inches of ironstone weathering into blocks, and full of comminuted fossils.
(*f*) Shales of Estuarine series.

(*a*) This sandstone has, I think, been noticed by Mr. W. H. Hudleston, F.G.S., in a paper on the Lower Oolites of Yorkshire, read before the Geologists' Association in November, 1873, and published in August, 1874. The bed is remarkable for the density of the upper part, which causes it to weather out as a small overhanging cliff in the steep sides of the gorges of the district, by which character alone it may be at once identified. The lower part being softer weathers away more rapidly. According to Mr. Hudleston the fossils found in it are *Pholadomya Sœmanni* and a *Modiola*, the latter of which I have found myself. The sandstone, however, contains but few fossils, and those very much scattered, and badly preserved.

The thin bed of Ironstone (*c*) contains a very large number of fossils, but in most cases the shell is replaced by a white earthy powder, or paste; and the complete preservation of the shell is rare, thus causing some difficulty in the identification of the species.

The following are the more abundant:—*Littorina* sp., *Astarte minima*,* *Nucula lachryma*,* *Trigonia striata*,* *Cardium** sp., *Cerithium quadrivittatum* (?), *Pinna cuneata* (?), *Gervillia acuta*, *Cucullœa*.

There are several other species, but undeterminable from their occurring only as casts. In the middle of the shale below is a thin aluminous band, very soft, and tasting strongly of alum.

(*e*) This bed of ironstone, first mentioned by Bewick, is a nearly white, hard stone, full of comminuted shells, and much resembling the lower part of the Pecten-band (Middle Lias) at Grosmont. Its characteristic, however, is the extraordinary abundance of a *Pholadomya*, which occurs chiefly in the weathered joints of the ironstone, and in such numbers that a hundred full-sized specimens may be collected in a few hours. It also contains a *Myacites*, vertically imbedded, in considerable numbers; the other fossils being much the same as those in the bed above, only not occurring in such good preservation.

This bed of ironstone is about 120 feet above the top of the Upper Lias in this district; the whole Estuarine series being much thinner than at Peak.

It is in Winter Gill, however, a small tributary of Glaisdale Beck, about five miles west of the Eller Beck section, that this marine bed attains its greatest known thickness, as well as its most interesting development. Unfortunately a climb of nearly 800 feet, over a rather rough road, will probably deter all but the more ardent spirits from studying the section that is here so well shown.

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tributaries. It has been seen in Hartoft Beck, at the head of Glaisdale, and of Grange Becks, and lately my colleague, Mr. C. F. Strangways, has found it in a small tributary of the Rye, where the ironstone is 2ft. 6in. thick, and has a close resemblance to a similar seam in the Middle Lias.

In the north and east the whole fossiliferous part of the bed thins away gradually, until, at Loftus Railway Station, there is a section of the shales with thin wedges of shaly ironstone, the whole being only two feet thick, and containing but few fossils; chiefly a small *Gryphæa*.

At Kettleness, however, there is a section showing the typical sandstone, ferruginous in parts, with about eight feet of shale beneath. About six to seven feet down in this shale is a thin band of fine dense ironstone-doggers; their base being a mass of fossils, mostly the small *Gryphæa*, but with occasional nests of *Astarte minima, Nucula minima, Littorina*, and a few other fossils, all small, and apparently dwarfed. Below this is a foot of shale, perhaps more, resting on a bed of hard ironstone, about a foot thick, sandy at the base, and the upper part having a blue tint and of an oolitic structure. Beneath this ironstone again is a mass of false-bedded sandstone.

I believe that this *Gryphæa* (?) is figured, but not specifically named, in Phillips's Geology of Yorkshire (3rd edit. pl. ix. fig. 26); and from its appearance always at the top or base of these thin marine beds, I feel sure it is essentially a brackish-water shell; and from its occurrence alone in the Loftus section, and being only accompanied by a few small species at Kettleness, we may venture to say that the bed dies out, or at least becomes less marine in character as we go north and east, and thickens south and west, as is proved by the rapidly increasing thickness of the fossiliferous ironstone going from the coast to Goathland, Glaisdale, and Ryedale. At the same time we believe it to become thinner again south of a certain point which we cannot yet accurately define; the whole bed forming an extremely thin but very persistent wedge, over the whole of the East Yorkshire area.

This sandstone bed is interesting archæologically, as its outcrop is often marked by old heaps of scoriæ; the thin bands of ironstone in the sandstone being the source of the ore: the two bands of ironstone that occur in the shale underlying never having been used. Holey Pits, near Egton Bridge, show a number of small holes formerly made in the sandstone in order to win or obtain the ironstone.

This short notice is sent in the hope that others may carefully study the fauna of the lower band of Ironstone, from which, in the Ryedale district, a large addition may be made to the present number of known species of fossils. A fuller description of the bed will be published in the Survey Memoir on the districts in which it is so well displayed.

V.—NOTES ON CRETACEOUS GASTEROPODA.

By J. S. GARDNER, F.G.S.

(PLATE XVI.)

IN May last I had the honour of laying before the Geological Society a description of all the known British Cretaceous *Patellidæ* and patelloid Gasteropoda. Since then the well-known collector, Griffiths, of Folkestone, has forwarded to me a new limpet from Hythe, which appears to belong to the genus *Hipponyx*. The finding of a shell of this genus is remarkable, as hitherto the shelly bases were he only indications of the existence of *Hipponyx* in Cretaceous rocks n England, whilst *Capulus Dunkerianus*, d'Orb., was the only shell on the Continent, of this age, which could be referred to the genus.

Hipponyx neocomiensis, sp. n. Pl. XVI. Fig. 1.
Lower Greensand, Hythe.

Conical, cap-shaped, very elevated, front flattened and compressed, posterior flattened and slightly hollowed, margin slightly quadrate. The cast shows the shell to have been very thick, and there are indications of coarse ribbings; the beak was probably solid and overhung the posterior margin. The dimensions are large, as seen by a reference to the figure. The great size of this and all Gasteropods from Hythe compared with those from other British Lower Greensand localities is truly remarkable.

Dentalium major, sp. nov. Pl. XVI. Fig. 2.
Cast bed, Grey Chalk, Dover.

Tubular, symmetrical, slightly curved, very gradually tapering; surface evenly striated near the apex, plain and rather rugose towards the aperture. This is one of the alated forms, remains of slight bordering keels being visible here and there on the figured specimen, and more perfectly on others. The tube was probably elliptical. Dimensions: length 4$\frac{3}{4}$ inches, breadth at aperture $\frac{3}{8}$th of an inch.

This is the largest *Dentalium* known, exceeding *D. grandis* from Japan in size by about an inch. Portions were found by me, during my last visit to Folkestone, in the cast bed, where it appears to be common. The figured specimen was found by Griffiths.

The Figures 3 to 18 are drawn from specimens kindly lent by Mr. Thomas Jesson, F.G.S., late of Trinity College, Cambridge, and unite, it appears to me, the following species from Cambridge.

1. *Crepidula gaultina*, Buvignier.
2. *Calyptræa Cooksoniæ*, Seeley = *C. sanctæ-crucis*, Pict. et Camp.
3. (?) *Crepidula alta*, Seeley.

The depressed form (Figs. 3, 4, 5, 20) known as *Crepidula gaultina*, also found at Folkestone, is perhaps a young form, and, from its flattened appearance, seems to have been fixed inside the apertures of shells. Figure 20 is taken from the specimen originally described by Seeley.[1] The higher form known as *Calyptræa Cooksoniæ*, Seeley (Figs. 6 to 19), may have been occasionally attached to the outside of shells, as similar differences according with the position of attachment may be seen in the forms of recent *Calyptræidæ* in the cases at he British Museum. No character is discernible by which the

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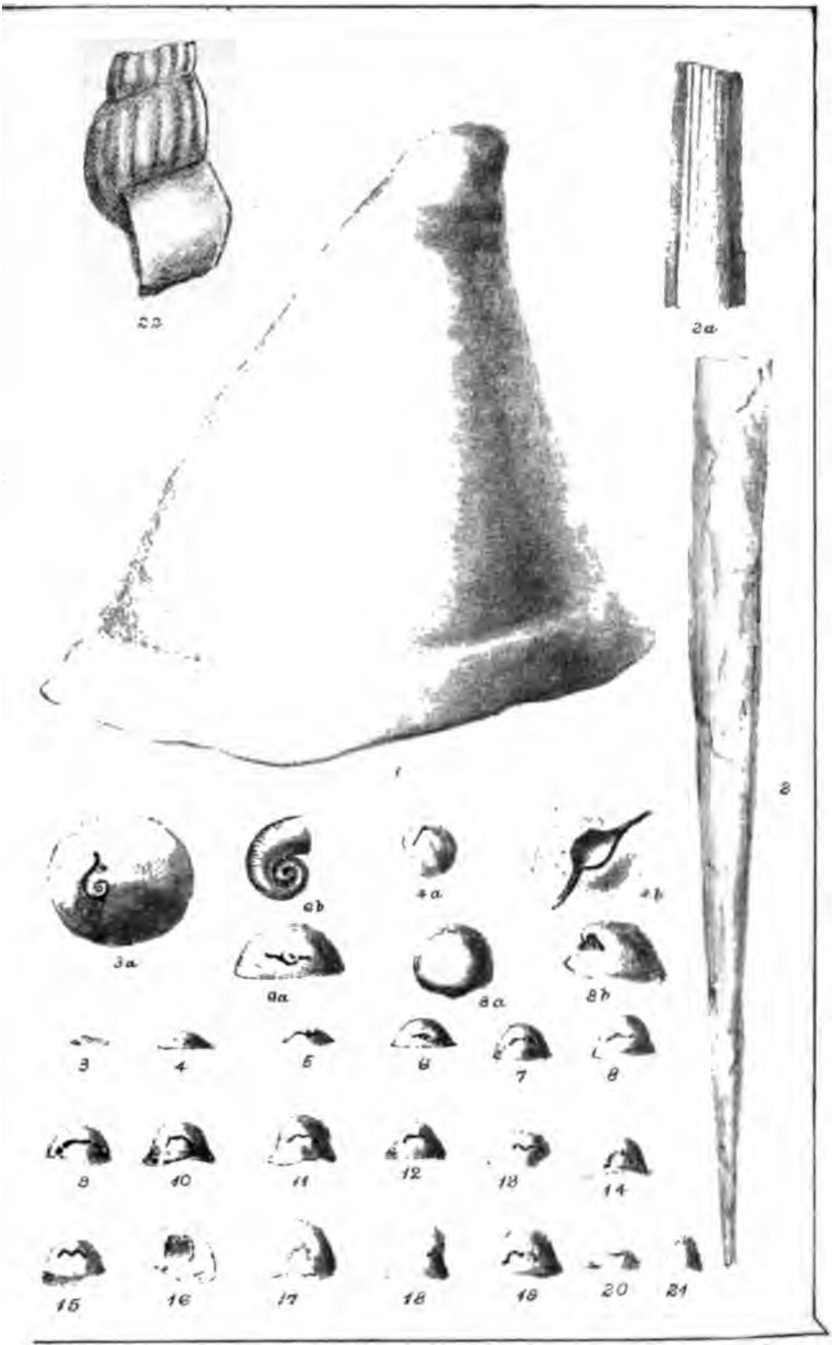
[1] See Q. J. G. S., May, 1877, p. 201.



W. West lith.

New Cretaceous Gasteropoda.

STANFORD

two may be separated. Fig. 19 represents the specimen originally figured by Prof. Seeley, which is lent to me by the kindness of the Curator of the Woodwardian Museum. Fig. 21 is a drawing of *Crepidula alta*, Seeley, which still remains an unique and perhaps a distinct shell, although I hesitate to accept it as such in a group, the individuals of which are liable to such extreme variation. Curious instances of this variation occur in the apertures of *Fusus longævus* from the Paris Basin, in the British Museum, in which *Capulidæ* are flattened and even take the crescentic form of the aperture of that shell.

Fig. 3*a* represents *Crepidula gaultina*, considerably enlarged and looking down upon it, and shows the helicoid apex which Dr. J. Gwyn Jeffreys notices as being common to all the limpets. In this species it is especially persistent, and is very distinctly visible in the cast, and also, but less so, in the perfect shells from Folkestone.

Fig. 6*b* is the apex alone, and shows the fine transverse ribbing with which it is always internally ornamented. Figs. 6*a*, 8*a*, 8*b* are other views showing the position of the helicoid apex, but are enlargements of shells said to be *Calyptræa Cooksoniæ*. Fig. 4*a* is a view looking down upon *C. gaultina*. Fig. 4*b* shows the crater-like scar, highly magnified, which is left on the cast after the removal of the helicoid spire. This is the imperfect state in which most specimens are found.

The great variety of scar left after the removal of the septum is well seen in this series. As I am informed by Mr. Jesson and the Rev. Arthur Buxton that the casts of these shells are abundant, when diligently searched for, in the apertures of Cephalopods in the Cambridge beds, there will be no difficulty in confirming the correctness of my proposal to unite the several forms in a single species. In this case Buvignier's name would have priority.

Fig. 22 represents *Brachystoma angularis*, Seeley. The genus was proposed by me in this MAGAZINE last year to receive this rare shell, and is placed in the family of *Aporrhaïdæ*. I had then no space to figure the Cambridge specimens (two in number), which are now in the Woodwardian Museum, and I embrace this opportunity of figuring one of them, as they are of larger size than the still unique specimen from the Gault of Folkestone.

VI.—ACROSS EUROPE AND ASIA.—TRAVELLING NOTES.

By Professor JOHN MILNE, F.G.S.;
Imperial College of Engineering, Tokei, Japan.

(Continued from p. 518.)

VII.—Irkutsk to Lake Baikal.

CONTENTS.—Irkutsk; its Earthquakes—Gold-washing in Eastern Siberia—Method of sinking to the bottom of a river through a shaft of ice—Road to Lake Baikal—Round its southern end—Old lake-terraces—Its former extension—Origin of its basin—Bearing of its Fauna on its origin—Is it a pool left behind a flood?

WHILST in Irkutsk I had many opportunities of conversing about the earthquakes which sometimes disturb these Central Asian localities. Not long before my arrival in the town, a sharp shocks had been experienced. The general effect it produced was given to me by Miss Cathleen Campbell, now Mrs. Szlenker, who had been keeping a record of meteorological and other phenomena. The shock took place at 2·55 A.M. on the 4th September. It was at first felt in a direction from east to west, but after 1¾ minutes it changed to N.E. and S.W. The shock, which was severe, caused ornaments on the table to rattle, and a few bottles which were close together knocked each other with so much force that they fell over. There were thirteen of them, and they tumbled in various directions —nine fell on the table, and four were broken on the floor. Watches and clocks were stopped, and screws 1¼ in. long, fastened in the wall to keep a clock straight, were drawn out. Preceding this shock, from observations which I saw, the barometer appears to have been lower than usual.

From a list of earthquakes drawn up by MM. Orlof and Stuikin as having occurred between the years 1725 and 1874, there appear to have been at least 188 different days on which shocks were distinctly felt. As these were all perceptible to the inhabitants, and not such as needed delicate instruments in order that they should be recorded, we cannot well make comparisons as to their frequency, but only as to their relative intensity.

The severest of these happened at the end of the year 1861. The district where the effects were most observed was near Irkutsk and along the shores of Lake Baikal. On the N.E. portion of the delta formed by the River Selinga where it enters the Baikal, the effects were permanent. This district, which was violently disturbed, is about forty versts long and 20 versts wide, and runs along the shores of the lake. On this strip of land were situated the Russian villages of Kudara, Doobeeneena, Oimoorchi, and a Bourat village, with a population amounting in all to 1300.

The first shocks, which were light, took place on the 29th of December. Next morning they were stronger, and on the succeeding night, that is, between the 30th and 31st, they not only increased in number, but their power also increased. On the afternoon of the 31st, at 3 P.M., a heavy underground rumbling was heard, and this was followed by a series of shocks so strong that it was impossible for persons to remain standing. Barrels in a yard, each containing twenty pouds (720 lbs.) weight of fish, were rolled backwards and forwards from one end of the yard to the other. In the yard and in the street the earth was cracked, and water charged with mud issued from the crevices thus formed. In some of the wells water rose like a "fountain" a fathom or more in height. Some of the fissures formed springs of clear fresh water, one of which, issuing from a crack about one arsheen (28 inches) wide, and two fathoms (12 feet) deep, gave so much water that a small lake was formed a verst in area. In the village of Krasnikova a hollow place twenty fathoms wide and three fathoms (18 feet) deep, with a spring in it, was formed.

In a church at the village of Kudara, the shocks were so strong that the cupola fell down inside, breaking a chandelier which was hanging beneath. In the houses at the same village so much mud and water came out of the cracks which were formed, that the boards forming the floors were burst, and the streets were covered with water one arsheen (28 inches) deep. On the same day the water of the Baikal flowed over the Sagansky Steppe and the Bourat villages which were situated upon it. On New Year's Day, 1862, the water of the Baikal flooded all the land as far as the Steppe of Bartogoisky. Three thousand five hundred head of cattle were drowned, and upwards of 40,000 hayricks were washed away, whilst corn and other things were also destroyed. Near to the Baikal the water was four arsheen deep (9ft. 4in.), and near Selinga ¼ arsheen (7 in.). The force of this flood of water was very great. Many pieces of ice several yards square and ½ arsheen (14 in.) in thickness were carried to distances of two versts (1⅓ miles).

The direction of the shocks was from N.E. towards S.W., through Cabansk, towards Selenginsk and Lake Gooseenoi. In Selenginsk the first shock was on the 30th December, at 4 P.M. Next day there were a series of slow shocks, which, in the afternoon, at 2 P.M., had increased in strength. Noises and tremblings were felt continuously. The church bell rang of its own accord, whilst the building itself swayed from north to south, and the crosses on its summit were tipped over to one side. The shocks were repeated rapidly, and, as night came on, they had so increased in strength that the earth oscillated every two or three minutes. By these strong oscillations the ice covering Lake Goosenaya and Lake Stuchya was cracked, and from the cracks came forth water charged with mud and pebbles. In Verkne Udinsk the shocks commenced at 4 P.M. on the 30th December, and during the day fourteen of them were observed. At 3 P.M. next day they were so strong that stone houses were cracked, stove pipes shaken down, and window glass was broken. Tremblings were observed so far as Chita and Nertchinsk. In Irkutsk observations were made by MM. Shookeen and Sementovsky. The tremblings commenced on December 30th, at 3 h. 55 m. 40 sec. P.M. The force of the shocks and the rapidity of the tremblings were unusual. The breaking of the ice upon the Rivers Angara and Ooshankofa caused great noise. During the night there were many shocks. At 2·19 P.M., on the 31st, the churches were shaken and the bells rang. From one church a cross fell down, the Arcanglesky Church inclined to the south, Blagovatschevsky and Teekveensky churches inclined east, whilst the cross on the last-mentioned building was turned round. A number of the brick houses were shaken, whilst the chimneys of the wooden ones cracked and fell. Slight shocks continued all day and next night.

In the Tunkinskaya country the effects were slight, and no visible results were left.

On the 30th Dec., in the Island of Olkoni (or Olkoon) on Lake Baikal, there was heard a noise, which was followed by a shaking. This continued until the 13th January, generally happening from 4 to 7 o'clock during the day. The greatest shakings were on the 31st December. Rumblings and slight tremblings were more or less felt, usually twice a day, until the 25th of January.

At the settlement of Ooreekofskim, which is about 20 versts from Irkutsk, an iron tie was torn from a church, and great damage was done. The southern boundary of the earthquake passed through Urga and Mongolia, and was perceptible at all places about the same time.

Earthquakes continued during the months of January, February, and even March, few days passing without shocks being felt.

In 1870 to 1871 strong shocks were also felt near Irkutsk. These were preceded by sounds like those of a powerful wind. Crosses fell from the churches, and the ice in the Angara, which was frozen at the time, moved up and down. One observer assured me that the upright planks, which formed the wall of the room in which he slept, had danced vertically up and down. When at the other extremity of Siberia, on my road towards Irkutsk, I had heard something about the violence of the earthquakes which I might perchance have the opportunity of experiencing. In consequence of the severity of the shocks I had also heard that the houses were only built one story high; but this is not the case, for I found that buildings soared almost as high in the Eastern capital as they do in the Western. All the earthquakes, like those of which I have spoken, have been accompanied by an underground noise. During the daytime the trembling of the buildings can be seen as well as felt. The smaller shocks, and more especially such as occur at night, are said to be indicated by the bellowing of cattle, the neighing of horses, and the howling of dogs. The general direction of the shocks is from N.E. to S.W. I was told that when only a slight shock was felt in Irkutsk, it often happened that something more severe was felt in the valley of the Tunka, about 80 miles to the S.W. This latter district is looked upon as being the centre from which the greater number of the Irkutsk earthquakes originate, a circumstance which may be supposed to have a connexion with the traces of volcanic action found in that district. Indications of volcanic forces are to be found at other points in the vicinity of Irkutsk, besides those in the valley of the Tunka: thus round Lake Baikal, in addition to old lavas, there are still hot springs and mineral waters. A liquid asphalt, which sometimes rises to the surface of the lake, is also referred to the same origin. On the Verkne Angara, south of Nijni Udinsk, and near Selenginsk, on the east side of the Baikal, there are also volcanic rocks; but I shall speak again of these presently.

Some few earthquakes appear to have originated from the neighbourhood of the Baikal, or even from the lake itself. These earthquake shocks occur at all times of the year, and are not confined to particular seasons, as they appear to be in many localities. After a great earthquake, as that of 1861, there is generally a period of quiescence, as if the internal forces were exhausted, and were therefore necessitated to await a fresh accumulation of energy.

The first record of an earthquake is that of 1725. This seems strange, insomuch as the town was built in 1686, and the place had been inhabited since 1652. From this we may infer that, prior to the date of the first shock, there must have been a quiescent period of at least thirty-nine years and perhaps more than seventy years. The only other explanation for this lapse of time, which is without an analogue in the subsequent history of the Irkutsk earthquakes, is that perhaps the records were either not kept or else have subsequently been lost. One remarkable statement I heard was that small earthquakes occurring on one side of Lake Baikal are not felt upon the opposite side. Such being the case, we might perhaps infer that there is some peculiarity in the depth or formation of the lake which prevents vibrations which originate on one side passing to the other. I shall have more to say about this lake bye-and-bye.

Since arriving in Japan, at certain seasons I have had almost a weekly experience of earthquakes. The month after my arrival, which was in March, 1876, there were no less than ten shocks recorded, whilst during the year there were fifty-three. Although these Japanese earthquakes are in most cases perceptible without the aid of instruments, they are by no means so strong as those I have been describing. They usually commence as a slight shock, which is followed by an easy short horizontal vibration, producing a sensation as if you were supported on a mass of stiffish jelly which had been slightly agitated. The timbers in your house crack, whilst glasses and windows rattle. This usually lasts for about thirty seconds, after which all is quiet. At first the sensation is curious, but by repetition it becomes unpleasant.

As at Irkutsk and other localities, the lower animals are affected. This is chiefly noticeable in the pheasants, which I hear screaming in my garden at every shock. They sometimes herald its approach a few seconds beforehand, and then usually continue their calling until the movement ceases.

When speaking of my journey across the Urals, I made reference to the gold-mines which I saw there. Although these mines were chiefly represented by alluvial workings, a few openings, as at Berezovski, had been made upon lodes of quartz. In Eastern Siberia this latter class of work has not yet been developed, but the former class has been very largely carried out. The chief workings are upon the Lena, as far north and even farther than Yakutsk, and in the Trans-Baikal and Amoor districts, as at Nertchinsk. Gold is also worked, but to a small extent, upon the Mongolian frontier. Here, however, but little has been done; chiefly owing to difficulties which arise with the Chinese and Native tribes, who, refusing to pay duty, wander backwards and forwards across the frontier, opposing or escaping all Government officials.

From all that I could learn, gold is found in greater or less quantities almost everywhere. The gold which comes from the northern districts, as the Lena, is generally the poorest, containing the greatest per-centage of silver and copper.

As an average analysis of 96 parts of East Siberian gold, I may give the following—

				TOTAL.
Amoor gold	$91\frac{2}{3}$ gold	4 silver	$\frac{1}{3}$ copper	= 96
Amoor gold	92 „	$3\frac{2}{3}$ „	$\frac{1}{3}$ „	= 96
Lena (Yakutsk) ...	$86\frac{1}{2}$ „	$9\frac{1}{6}$ „	$\frac{1}{3}$ „	= 96

This would suggest that the constancy in the general character of the gold obtained from the Lena, as compared with that from the Amoor, is either due to their having originated from different sources, or, what is perhaps as probable, that those great causes which acted in laying out the beds of alluvium in which they occur, also acted in separating the various qualities of gold according to their respective specific gravities, that which was light being carried farthest from its source as compared with that which was heavier. If there is any probability of such an action ever having taken place, then we might suppose that the gold of the Lena district has travelled farther from its origin than that in the Amoor.

In the consideration of such an action, the average relative sizes of the transported particles is an important factor. In the gold of Eastern Siberia such metals as platinum or iridium, which are so common in the Urals, are but seldom found. A little is, however, obtained from the washings at Nertchinsk.

Whilst in Irkutsk I paid several visits to the smelting works, where all the gold of Eastern Siberia is cast into ingots. There is a similar establishment at Barnaul for Western Siberia. At these works I had every opportunity kindly given me of examining large quantities of gold from various localities. The bulk of what I saw was more or less roughly granular, many of the grains being as large as peas. I saw many indications of the formation of crystals, from which I concluded that such gold had not travelled very far from the position in which it had been originally deposited.

The gold mining all over Russia is under Government control, which always specifies that, after obtaining a grant of land, one must commence to work upon it within a given time. The places which are generally worked are the banks and beds of small tributary rivers, but more especially the beds. Near the mouth of the river the yield is generally less than it is higher up. In such places the alluvium may be sixty feet in thickness, whilst the bed containing the gold, which may be below all this, is only perhaps seven feet in thickness. The workings generally commence at the mouth of a stream, and work up the valley down which it flows towards its source. The first operation is to sink a number of trial shafts at right angles to the direction of the valley. These go down to the bed rock. From the gold-sand which generally lies upon this rock samples of 10 pouds each (360lbs.) are taken, then washed, and afterwards the yield for 100 pouds is calculated. After this has been done at several points, and the results are satisfactory, a dam is thrown across the river, and the water is sent round one side, along the edge of the valley, instead of down the course in which it originally ran. If near the dam they have to sink, say, for example, thirty feet, in order to reach gold, then they must also sink thirty feet below the bed at some point below these workings, and from it cut a drain in order to carry off any water which may accumulate at the point where they are extracting the gold.

This is only one system which is adopted in mining and prospecting. There are others specially for prospecting, which are noteworthy from their ingenuity. One system in particular to which I refer is that adopted for sinking shafts in the beds of rivers without the necessity of making a dam. This is done in winter when the waters are frozen. First of all holes are cut in the ice the size of the prospecting shaft, to within two or three inches of the water. The shallow pit thus formed is then allowed to rest for a day or two, when underneath the portion that is cut away the water freezes, and the ice is again thickened at the point where it had been made thin. There is now material in which to deepen the excavation, which is again carried on to within two or three inches of the water. Once more it is allowed to thicken, and the shaft is continued. In this way the bed of the river is reached, by means of a tube of ice, round the outside of which water is flowing. Whilst the operation is going on, a small hole is occasionally made through the floor of ice to test its thickness. After this has been measured, the orifice is immediately stopped up with a plug of ice, and the excavation continued or allowed to rest, according to circumstances. In this way I am told that many of the rivers are tested during the winter months. When good ground is found, the river is dammed up and the works proceed as I have before described.

Although Siberian cold is thus turned to account by the prospector, it is often a great bugbear to the miners. In the north gold mining is carried on in ground perpetually frozen. After this has been excavated, before it can be washed, it has first to go through a process of thawing. Exposure to the atmosphere is sometimes sufficient for this purpose, but at other times it has to be subjected to a process of firing.

Some of the Tungusians are said to have great skill in prospecting, which they do in a truly philosophical and scientific manner, their chief guide being the general contour of the country. Ascending a high hill, they look down upon the country beneath, intersected with its network of streams and valleys. They then observe those places in the valleys where a line of hills, a projecting ridge, or any other object, would be likely to offer an obstruction to the passage of materials which may at any time have come sweeping down from higher ground. These positions are then marked, and afterwards examined on similar principles, but in detail, and the results are generally said to be most satisfactory.

After nearly a month's residence in Irkutsk, I at last left it at 11 P.M. on the 23rd of November, and took the road towards Kiachta. As there was now so much floating-ice upon the Baikal, and it was in consequence doubtful whether the steamer would be able to cross, I was forced to take the road running round its southern end. Although I was now travelling in a sledge, to which I had anxiously looked forward as a pleasure compared with a tarantass, I found the jolting still unpleasantly heavy. When daylight came, I found myself in a hilly pine-covered country. In the distance before me, and also a little to my right, there were many snow-capped peaks, none of which appeared to rise above a common level. From the cuttings which had been made during the formation of the road, I

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It was along this southern end of the Baikal that I met with the best scenery in crossing Siberia. About halfway along the shore I left what I have spoken of as a ledge, and descended to the level of the lake. In places the shore was covered with large boulders, whilst in other parts it was sandy. Sometimes I crossed the mouth of a small valley, which marked the entrance of some tributary from the south. Here, instead of tall pines, which flanked the steeper portions of the road, there were clumps of birch, which swung their drooping branches, thick with hoar-frost, in the breeze. At night-time, charging deep gullies in the dark, the roaring of the waters on the shore, the intense cold, the loneliness, and the generally cramped position in which I was obliged to sit both night and day, had a miserable and depressing effect. Along the road I only met two men, and this happened under circumstances so suspicious that I congratulated myself when they were well passed. After rounding the southern end of the lake, I had a full view of the cliff-faced hills upon the western side, which were then capped with snow. Nearer to me I had small fields of ice, some of which were a square mile or more in area, and amongst which a few blocks stood up like icebergs in miniature.

When speaking of the freezing of Siberian rivers, I mentioned the fact of the Baikal freezing over at different times in different parts. Thus in the vicinity of the Island of Olkoon it freezes about the 23rd of December, and breaks up from the end of April to the 10th or 15th of June, whilst near Posolsky, farther to the south, it freezes from the 22nd of December to the 10th or 16th of January, and breaks up between the 20th of April and the 10th of May. There are small places in the lake where it is said never to freeze, and about such places the seals, which inhabit these waters, are said to congregate in winter-time. These unfrozen patches are, I believe, looked upon as marking the position of warm springs. In some portions of the lake there is a slight increase in temperature as you descend. The experiments showing this were made at 1000 mètres from the shore in water ninety fathoms deep. At about ten mètres from the surface the temperature was ·7 Cel., and this increased as you descended until the bottom was reached, when it was 3·1 Cel.

At all the post stations I made inquiries about the seals which inhabit the lake, but I did not see anything more than a few of their skins. I also asked about shells and fish, and I was successful in obtaining a few of the former.

Speaking of the Lake Baikal seal, Mr. Wallace, in his Geographical Distribution of Animals, vol. i. p. 218, says: "It is a species of *Callocephalus*, closely allied to, if not identical with, one inhabiting Northern seas, as well as the Caspian and Lake Aral. This would indicate that all Northern Asia was depressed beneath the sea very recently; and Mr. Belt's view, of the ice during the Glacial epoch having dammed up the rivers and converted much of Siberia into a vast freshwater or brackish lake, perhaps offers the best solution of the difficulty." Before at once accepting these views of Mr. Wallace in the adoption of Mr. Belt's idea as to the origin of the Siberian Steppes, to which latter I have already referred at length, I will relate the few facts I collected, all of which, I think, have a bearing on this interesting speculation.

When at Irkutsk I saw a Baikal seal. It was short and thick, and said to be a young one. It had a generally greyish colour, but rather darker on the back than upon the other portions of its body. As the seals grow older, the body deepens in colour. One thing that I was distinctly told was that they are never marked with spots or patches.

The only seal that I have seen which is anything like the Baikal Seal is the so-called bay seal of Newfoundland and Labrador, which often ascends rivers and permanently inhabits inland lakes. Speaking from memory, which is unfortunately of but little value in making the nice distinctions which are required when establishing the identity or distinction of two species, these latter seals are more elegant in their proportions than those from Lake Baikal, and, what is more, at certain periods of their existence, they have various markings developed on their skin—a feature which is absent in the Baikal seals.

The head-quarters of the seal in the Baikal Lake are at its northern end, but in winter they collect round those portions which are said to remain unfrozen.

I also heard that seals are found in Lake Kosogol, across the borders, further to the south; they are also reported as existing in another lake lying to the east, and in the Oron Lake to the north-east. If this is true, and, from the relations which the fauna of other lakes bear to that of the Baikal, it is not unlikely, then we shall have a striking piece of evidence indicating to us the probable way in which these lakes may have originated.

Across the northern end of the lake a series of soundings have been made by M. Debovsky, of Irkutsk, who also examined its fauna. The greatest depth attained at this end was 1373 feet. In some places it is stated as being 800 fathoms. This is very deep, but if we were to draw a section across the lake, which would be about forty-five miles long, the magnitude of this would be seen to be more or less apparent. The bottom consists of various materials, such as pebbles, clay, rocks, and sand. The fish of the lake form a great trade, and supply many vessels upon its waters. Many of these vessels come down the Angara as far as Irkutsk, where they discharge their cargo. The commonest of these fish, which I had many times the pleasure of eating, were *Coregonus omul* and *Lota vulgaris*. These two fish, which are known respectively as the omool and naleem, are to be seen in the house of every Siberian, and they are esteemed so much that they may sometimes be found amongst the Russian residents in China. The omool is peculiar, I believe, to the Baikal; but the naleem is found farther west. Other fish inhabiting the lake are: *Idus melanotus*, *Acanthopsis tænia*, and *Perca fluviatilis*: these are also found farther west. *Salmo* *fluviatilis*, *Salmo coregonoides*, a *Cottus*, and *Thymallus* are also found in the lake.

Besides the seal, called by some *Phoca Baicalensis*, and the omool, which may be regarded as being so far peculiar to the lake, *Coregonus Baicalensis*, *Squalidus Baikalensis*, and *Calorrhous Baikalensis*, along with other creatures, are also peculiar.

There are also many Crustaceans which have hitherto been only found in the Baikal. Amongst these there are, I think, seventy or more species of *Gammarus*. These latter, many of which I saw, are generally of a light yellow colour. They live in holes in the sand or clay. They are very ravenous. If a dead body is sunk in the lake, the whole of the flesh is devoured in a few days, and only a skeleton remains. It was by lowering a carcase like that of a sheep into the lake, and by taking advantage of the flesh-eating tendency of these creatures, that many new species were captured. Osteological specimens have been prepared by sinking them for a few days in the lake. This was very satisfactory, as the whole of the flesh was removed without any attack being made upon the outer portion of the bone, as ants are very apt to do.

Some of these, like *G. verrucosus*, *G. viridis*, and *G. cancellatus*, live near the shore in shallow water, whilst others appear to only inhabit the deeper portions of the lake. In addition to the Crustaceans, Lake Baikal yields a peculiar series of Mollusca.

Some interesting experiments have been made here by M. Debovsky as to the depth at which these creatures can exist. One of these experiments was to place living specimens of *Paludina Baicalensis* and *Choanomphalus Mackii* in a bag and sink them to various depths between 700 and 1200 feet, and there allow them to remain for several weeks. The result of this was that the subjects survived in an apparently healthy condition.

Some Crustaceans, similar to those in the Baikal, have been found in a small lake up the Tunka Valley, and I have already mentioned that it is not at all unlikely that seals also occur in neighbouring lakes.

These facts, small as they are, naturally tend to the surmise that the fauna of the inland fresh waters of these districts may, on examination, prove to have a great similarity. Should this be so, we may perhaps be led to think, as has before been suggested, that all the small lakes which we see dotted on the map around the Baikal were once connected, and in former times existed as a vast inland sea. That the Baikal was once more extensive than it is at present seems to be indicated in the terraces which appear to be marked upon its southern boundaries. Still farther to the south and south-east, up the valley of the Tunka, Mr. Tchersky tells me that there are beds of alluvium marking an old extension of the lake.

So far as I could learn, there appear to have been two well-marked periods in the history of this lake: first there was the original cutting out of the rocky bed, and a subsequent filling in with alluvium, and secondly there was the cutting out of the basin in the alluvium, traces of which remain in the valley of the Tunka, and a sinking of the waters to their present level. By this latter action we had the water, so to speak, split up into separate areas. This would explain the similarity in the fauna of the different districts, should it ever be proved satisfactorily to exist, and also the presence of salt lakes in the Trans-Baikal territory, where the waters for want of outlet have become gradually supersaturated, until now they annually form a deposit on their shores.

Most of what I have said about the Baikal, it will be seen, is based on scanty evidence, and must only be accepted until something better can be obtained. When the geology and zoology of these districts have been further investigated, it remains to be seen if we get indications as to the origin of the physical features of this part of the world still pointing in the same direction, as those do which we have at present in possession.

So far, then, I am content to believe that at one time, in this portion of the world there were inland fresh waters which deposited alluvium, and as these retired, the Baikal, with its surrounding lakes and lakelets, were left like pools behind a flood.

REVIEWS.

I.—Sections of the Northumberland and Durham Coal-field. By J. B. Simpson, M.E. (Large folding sheet, published by A. Reid, Newcastle-on-Tyne. 1877.)

THE times when mining engineers jealously kept their local knowledge to themselves are rapidly passing away, and it is but rarely now that information of a scientific character is withheld from the public. The publications of the Geological Survey teem with acknowledgments of assistance rendered by the very men who, years ago, would have thought it their duty to oppose obstacles to the progress of such work. There are still exceptions, but they are few and far between—survivals, but not of the fittest. The issue of the handsome sheet before us is a case in point. Here Mr. Simpson, well known as one of the most active of North-country mining engineers, and the author of more than one paper of geological interest, has given the world a key to the structure of the great Northern Coal-field, of which it is difficult to speak with sufficient praise. In the right-hand corner of the sheet an index geological map shows the limits of the field, its chief lines of fault and the lines of section, one N. and S., and the other E. and W., the detailed illustration of which forms the chief object of the plate. This object is attained by means of nearly fifty actual measured vertical pit-sections carefully drawn to scale, and placed side by side in order across the sheet. To the left stands a general section in which every recorded Coal-seam is given and numbered, corresponding numbers being used in all the other sections for the same beds, thus enabling one to ascertain at a glance the author's views as to the equivalence of the minor seams. This is perhaps the most valuable feature of the publication. As a datum-line the Low-Main or Hutton Seam has, we think very properly, been chosen.

Two longitudinal sections along the lines mentioned give a good idea of the general connexion of the details.

As a whole, the structure of the Tyne, Wear, and Tees Coal-field is simple enough, and since Buddle's remarkable papers on the larger seams of the district, the general equivalence of these has been fairly well understood. With the minor seams, however, this is not the case, and every one will appreciate the obligation under which Mr. Simpson has placed northern geologists and mining men in giving them the results of his observations on the subject. In some instances even now the correlation of the seams is still doubtful, especially in the extreme north. When this is so, a special mark attached to the sections denotes the uncertainty.

The nomenclature of Coal-seams has ever been eccentric, and here we have this brought vividly before us. The names in use in the Tyne district are not those of the Wear Valley, while yet other names are given to the same Coals in the Derwent area.

The care with which this chart has been drawn up is evidenced by the fact that even the small seams lying between the Brockwell seam (the arbitrary base of the Coal-measures) and the Millstone-grit are duly entered in their places. In this interval we have the group of beds sometimes referred to as the Ganister series, although the rocks composing it are indistinguishable from those either above or below, and no marine fossils have, so far as we are aware, been found in them yet. The fine-grained white, rootlet-pierced, sandstones, which give their name to the division, are found both in the beds above the Brockwell seam and in the Carboniferous Limestone or Bernician rocks far below. We are therefore pleased to see that Mr. Simpson includes the series (some 300 feet thick) in the Coal-measures proper, in which, indeed, he has, very judiciously, recognized no divisions whatever. The entire thickness of the Coal-measures, according to him, from the highest bed known in Boldon Colliery (between Sunderland and Newcastle), and the top of the Millstone-grit, is about 2125 feet. What thickness of upper beds was removed before the deposition of the Permian deposits (the unconformity of which is well shown in these sections), there is of course no means of knowing.

Mr. Simpson's diagram, while it is indispensable to all local inquirers, cannot fail to be appreciated by geologists and mining engineers everywhere as the latest, readiest, and most accurate summary of all that is important respecting the Newcastle Coal-field.

G. A. L.

II.—On Volcanic Action as a Phenomenon of the Universe. By Prof. Gustav Tschermak, Member of the Imperial Academy of Sciences. Read 8th March, 1877. (From vol. lxxv. of the Transactions of the Imperial Academy of Sciences, 1st part, March number, 1877. Vienna.)

THE author has formerly suggested that all stars in the course of their development pass through a volcanic phase. The moon's mountains have been thought by Hooke, Nasmyth, and Carpenter, to owe their shapes to eruptions. The sunspots are eruptions of incandescent gas: the sudden brilliancy of some stars points to a similar cause. The forms and materials of meteorites may be due to ejection from some planet in volcanic activity, perhaps now itself reduced to fragments. He will consider which of the many hypotheses brought forward will bear application to the earth and extension to the universe. First he describes the theory which attributes volcanic phenomena to the mutual action of the water which percolates down and the heated rock which it meets. This explains many of the circumstances. He objects to it, however, that since percolation is a continuous process, volcanic activity ought either to be continuous or regularly periodic, also that it fails to explain the origin of many products of eruptions, especially carbonic acid gas, nitrogen, ammonia, sulphurous and sulphuric acids, etc., and that the moon shows numerous volcanos but no water.

Next he describes Mallet's suggestion that the heat is owing to the sinking of portions of the earth's crust into cavities produced by contraction. This he says could not develope a temperature nearly sufficient; its weakness has been shown by O. Fisher and Roth, and it offers no explanation of the chemical products. He briefly dismisses the suggestion of Nasmyth and Carpenter, that the moon's materials *expand* in solidifying; as also that of Davy that the earth's interior contains potassium.

He then enunciates his own hypothesis, first developed by Angelot in 1842, that the molten materials within the earth contain absorbed in them quantities of vapours or gases, which, in solidifying, they disengage. Angelot thought this would not account for the amount of action, but he himself considers that he has calculated that it will. The irregularity of eruptions he attributes to the irregularities in the interior. He adduces the quantities of gases found contained in meteorites. He explains on this hypothesis the disengagement of gases from lava, its origin, and its behaviour. Especially he urges the agreement of his theory with the hypothesis of Kant and Laplace—the origin of all heavenly bodies by condensation of gases. In their solidification these bodies would include quantities of the simple gases, which at those temperatures would be elements, but when disengaged in cooling might meet, combine, and so produce great and sudden developments of heat. The application to solar eruptions is plain. If small bodies were so formed, their quicker cooling might cause explosive action more violent than ordinary, resulting in swarms of irregular fragments, and perhaps the complete destruction of the bodies. Thus he accounts for meteorites. The small attraction of such bodies would be insufficient to retain water unvapourised on them. Now meteorites, he says, contain generally anhydrous minerals. If the moon be derived from a former ring (like one of Saturn's) round the earth, its materials would be light. If its surface consist of light absorbent materials, these may retain the steam and gases disengaged from the interior, and account for the absence of a visible atmosphere.

In Appendix I. (pp. 18-20) the author estimates the degree of temperature that could be produced on Mallet's hypothesis. He calculates that a mass 100 square miles in area, sinking 1 mètre, on the assumption that half the heat developed was produced by friction, and that its effect extended to a distance of one mètre on each side of the surface of rupture, could not produce along this surface a rise in temperature of more than 54·7° Centigrade.

In Appendix II. (pp. 20-24) he cites many observations which show that molten metals contain considerable quantities of different gases, and disengage them in cooling and solidifying.

In Appendix III. (pp. 24-26) he shows that on the supposition of a large number of assumptions the amount of gas developed from the earth would be more than sufficient to account for the volcanic activity we see. His assumptions are, Poisson's calculation of the heat lost annually by radiation: that the additional amount lost by hot springs, lava vents, etc., is one-tenth more: that the latent heat of consolidation is that of iron (which he estimates ingeniously): that the molten materials at great depths disengage in solidifying 50 times their volume of gas: and that the velocity of eruption of gas from a volcanic vent is fifteen mètres per second. His result is that the gas disengaged would be sufficient to keep in vigorous activity 20,000 volcanic vents, each one square mètre in area.

Though the author's theory is open to some of the objections which he urges against other hypotheses, and though his calculations, as is apt to be the case with such estimates, are of little importance, yet it does seem likely to be a partial cause of terrestrial volcanic activity, perhaps the whole cause of solar eruptions; and the paper, as a clear statement of the theory, is a valuable one.

E. H.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.—November 7th, 1877.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.

The President announced that Mr. Frederick L. Woodward had been appointed Junior Assistant in the Library and Museum.

The following communications were read:—

1. A letter dated Foreign Office, September 14, 1877.

"Sir,—I am directed by the Earl of Derby to state to you, for the information of the Geological Society, that his Lordship has received a despatch from Her Majesty's Minister at Teheran, reporting that a mining engineer had arrived there from Berlin, who, at the request of the Persian Government, had been selected by Messrs. Siemens to ascertain what foundation there was for the reported existence of a rich vein of gold in the vicinity of Zengan; that he had visited the locality, and reported that auriferous quartz does exist, but that he had not yet succeeded in finding any vein or deposit of the metal.—I am, Sir, your most obedient, humble Servant,

"The Secretary, Geological Society, etc. Julian Pauncefote."

2. "Notes on Fossil Plants discovered in Grinnell Land by Capt. H. W. Feilden, Naturalist to the English North Polar Expedition." By Prof. Oswald Heer, F.M.G.S.

Near Discovery Harbour, where H.M.S. "Discovery" wintered in 1875-6, in about 81° 45′ N. lat., and 64° 45′ W. long., a bed of lignite, from 25 to 30 feet thick, was found, resting unconformably upon the azoic schists of which Grinnell Land chiefly consists. The lignite was overlain by black shales and sandstones, the former containing many remains of plants; and above these there were, here and there, beds of fine mud and glacial drift, containing shells of marine Mollusca of species now living in the adjacent sea. This glacial marine deposit occurs up to levels of 1000 feet, indicating a depression and subsequent elevation of the region to at least this extent.

Remains of 25 species of plants were collected by Capt. Feilden, and 18 of these are known from Miocene deposits of the Arctic zone. The deposit is therefore no doubt Miocene. It has 17 species in common with Spitzbergen (78° 79′ N. lat.), and 8 species in common with Greenland (70° 71′ N. lat.). With the Miocene flora of Europe it has 6 species in common; with that of America (Alaska and Canada) 4; with that of Asia (Sachalin) 4 also. The species found include 2 of *Equisetum*, 10 Coniferæ, *Phragmites Œningensis*, *Carex Noursoakensis*, and 8 Dicotyledons, viz. *Populus arctica*, *Betula prisca* and *Brongniarti*, *Corylus Macquarrii* and *insignis*, *Ulmus borealis*, *Viburnum Nordenskiöldi*, and *Nymphæa arctica*.

Of the Conifers, *Torellia rigida*, previously known only by a few fragments from Spitzbergen, is very abundant, and its remains show it to have been allied to the Jurassic genera *Phœnicopsis* and *Baiera*, the former in its turn related to the Carboniferous *Cordaites*, and among recent Conifers, to *Podocarpus*. Other Conifers are, *Thuites Ehrenswärdi* (?), *Taxodium distichum miocenum* (with male flowers), *Pinus Feildeniana* (a new species allied to *P. strobus*), *Pinus polaris*, *P. abies* (twigs covered with leaves), a species of *Tsuga* (*Pinus Dicksoniana*, Heer), and a white Spruce of the group of *Pinus grandis* and *cariocarpa*. *Pinus abies*, which occurs here and in Spitzbergen, did not exist in Europe in Miocene times, but had its original home in the extreme north, and thence extended southwards; it is met with in the Norfolk Forest-bed, and in the interglacial lignites of Switzerland. Its present northern limit is 69½° N., and it spreads over 25 degrees of latitude. *Taxodium distichum*, on the contrary, spread in Miocene times from Central Italy to 82° N. latitude, whilst at present it is confined to a small area.

Betula Brongniarti, Ett., is the only European species from Grinnell Land not previously known from the arctic zone.

The thick lignite-bed of Grinnell Land indicates a large peat-moss, probably containing a lake in which the water-lilies grew; on its muddy shores stood the large reeds and sedges, the birches, poplars, *Taxodia*, and *Torelliæ*. The drier spots and neighbouring chains of hills were probably occupied by the pines and firs, associated with elms and hazel-bushes. A single elytron of a beetle (*Carabites Feildenianus*) is at present the sole evidence of the existence of animals in this forest-region.

The nature of the flora revealed by Capt. Feilden's discoveries seem to confirm and extend earlier results. It approaches much more closely to that of Spitzbergen than to that of Greenland, as might be expected from the relative positions of the localities; and the difference is the same in kind as that already indicated by Prof. Heer between Spitzbergen and Greenland, and would indicate the same kind of climatic difference. Nevertheless, the presence of *Taxodium distichum* excludes arctic conditions, and that of the water-lily indicates the existence of fresh water, which must have remained open a great part of the year. Representatives of plants now living exclusively in the arctic zone are wanting in the Grinnell-Land deposits; but on the other hand most of the genera still extend into that zone, although they range in Grinnell Land from 12° to 15° further north than at present.

3. "On our present knowledge of the Invertebrate Fauna of the Lower Carboniferous or Calciferous Sandstone series of the Edinburgh neighbourhood, especially of that division known as the Wardie Shales, and on the first appearance of certain species in the beds." By R. Etheridge, Esq., jun., F.G.S.

The Calciferous Sandstone series of the district described consists, according to the author, of two divisions:—the superior, or "Cement-stone group," composed of sandstones, shales, oil-shales, some thin coals, and a few limestones; the inferior, or "Red Sandstone," consisting of red and grey sandstones, conglomerates, marls, and cornstones. The latter are very unfossiliferous, an Entomostracan (*Estheria Peachii*) being the only fossil known from the Red Sandstone. In some sandstones and shales at Clubbiedean Reservoir, placed with doubt at the base of the Cement-stone group, *Leperditia scotoburdigalensis* and a crushed bivalve (*Myalina* ?) occur with *Sphenopteris affinis*; and a limestone belonging to the same set of beds is almost entirely composed of *Spirorbis helicteres* with *S. carbonarius* (?). In shales at Craiglockhart Hill, *Discina nitida, Lingula squamiformis* (?) and *mytiloides, Anthracosia nucleus, Avicula Hendersoni*, and a new *Myalina* occur. In the Wardie Shales at Woodhall *Serpulites carbonarius*, a species of *Chætetes*, a new species of *Leda, Myalina crassa*, var., a species of *Aviculopecten, Schizodus Salteri, Pandora typica*; *Pleurotomaria monilifera, Murchisonia striatula* (?), *Bellerophon decussata*, var., a species of *Conularia, Nautilus cariniferus*, and a species of *Orthoceras*, make their appearance, associated with several of the previously mentioned fossils. This appears to be the richest deposit in the whole group; but a new species not found in it occurs elsewhere. The author has increased the known Invertebrate fauna of the Calciferous Sandstone group in this district from twenty to thirty species, most of which he describes and figures, and among them the following are distinguished as new or undetermined:—*Chætetes* sp., *Avicula Hendersoni, Aviculopecten* sp., *Anthracoptera obesa, Myalina sublamellosa, Nuculana Sharmani, Pandora? typica, Littorina? scotoburdigalensis, Conularia* sp., and *Orthoceras* sp.

From his investigation of these species he indicated the occurrence of at least three or four marine beds in the Calciferous Sandstone series in addition to that mentioned by Mr. Salter, namely, at Craiglockhart, at Woodhall, Water of Leith, at Drumsheugh, which may be identical with the last, and probably at Dean Bridge. Several of the species which occur low down in this series attain their greatest development in, and are characteristic of, the Carboniferous Limestone series.

II.—American Association for the Advancement of Science, Nashville, Tenn., August 31, 1877.—Prof. T. Sterry Hunt read a paper on "The Geology of the Older Rocks of Western America," of which the following is a synopsis:—

Prof. Sterry Hunt called attention to the great types of crystalline stratified Eozoic rocks which he has recognized in the eastern part of the continent and in Europe, and which he has endeavoured to show constitute distinct groups, well marked, both lithologically and geognostically. He then gave some conclusions drawn from observations made by himself at a few points among the crystalline rocks during a late journey in the West. His examinations of those in the Rocky Mountains were made in the Sangre de Christo Range, near Garland; in the Front or Colorado Range; at the Ute Pass and Glen Eyrie; and also along Clear Creek Cañon, and about Georgetown. In all of these localities he found gneissic rocks, frequently granitoid, often hornblendic, but scarcely micaceous, and apparently identical with the Laurentian series of the East. He referred to the published observations of the late Mr. Marvine, in Hayden's Report for 1873, who had carefully studied these rocks in the Colorado Range, and who compared them to the Laurentian; and he agreed with Mr. Marvine in regarding as indigenous the red granitoid rocks in the region of the Ute Pass. Similar granitoid rocks at and near Sherman, on the Union Pacific Railroad, are also, according to Prof. Hunt, probably of the same nature. He referred in this connexion to the area of labradorite rocks having the character of the Norian series, found in the Rocky Mountain region, in Wyoming, but known to the speaker only through specimens.

The rocks of the Wasatch Range, as seen in the Devil's Gate on the Weber River, are Laurentian, to which are to be referred also the crystalline stratified rocks found in the same range further south, in the upper part of the Little Cottonwood Cañon. Here, among loose blocks of the gneiss, are found occasional masses of coarsely crystalline limestone, with mica, and others of a peculiar type of pyroxenic rock, which accompanies similar limestones in the Laurentian series. The crystalline rocks in the lower part of the same Cañon are, however, well-marked exotic or eruptive granites.

Eruptive granites are found in California, where they abound among the foot-hills of the Sierras, in Placer and Nevada counties. The crystalline schists seen by the author in these counties, and in Amador county, are Huronian, and have all the characters of the Huronian series, as seen in the eastern regions of North America, and of the *pietri verdi* of the Alps. To this horizon are also to be referred the similar crystalline rocks of the Coast Range of California, as seen near San Francisco and San Jose. The auriferous veins which, in the Rocky Mountains, intersect the Laurentian gneisses, are found in the Sierras alike in the Huronian schists, and in the granites which probably penetrate the Huronian series.

CORRESPONDENCE.

THE LATE MR. EDWARD WOOD, J.P., F.G.S.

Sir,—Your obituary notice (Geol. Mag. Oct.) of the late Mr. Wood, of Richmond, omits a circumstance in his life which the riter may not have known—but which ought not to be left unecorded.

Mr. Wood was a man with a warm and feeling heart; and some ears ago, when it was the fashion for ladies to wear seabirds' wings n their hats, gangs of merciless ruffians used to put out in boats om the coast towns of the north-east of England for the purpose f capturing the birds (which breed on Flamborough Head) while tting on their nests. Not satisfied with this, they would often ear the wings from the bodies, retaining only the former, and hrowing the latter into the sea.

During Mr. Wood's geological excursions he became a witness to his revolting practice, which he determined if possible to put an end o. He foresaw that unless this was done the whole race of seairds on that coast would be exterminated. He immediately put imself in communication with gentlemen of influence in that part f the country, described with natural indignation what he had seen with his own eyes, and obtained their aid in bringing the matter efore members of Parliament. He also went up to London and ad interviews with members of the Government and of both Houses of Parliament, and at length had the satisfaction of seeing a bill carried into law, for the protection of seafowl during the reeding season. All who love the feathered tribes, therefore, owe debt of gratitude to Mr. Wood, of Richmond, Yorkshire.

Dublin, *14th October*, 1877. E. H.

RIPARTITE ORIGIN OF THE BOULDER-CLAYS OF THE NORTH WEST OF ENGLAND.

Sir,—From repeated examinations of a number of constantly arying sections around the estuaries of the Dee and Mersey, I have een led to adopt the theory of a tripartite derivation of the contituents of the two Boulder-clays—the normal *sand and coarse grit* rom the *local* Triassic, Permian, and Carboniferous sandstones; the bnormal *clay* (of which the deposits mainly consist) from "mud" suing from beneath glaciers (chiefly in the Lake District) when hey descended as low, or nearly as low as the sea-level; the equally bnormal *erratic stones* transported and dropped into the slowly ccumulating clay by floating coast-ice, the sea having been too hallow to float icebergs, which indeed would either directly or ndirectly have disturbed the surface of the middle sand (which, way from the mountains, almost invariably indicates the prevalence f extremely tranquil conditions) when the upper clay began to be eposited. The *clay* may have been partly worked up from the ocal shales and so-called marls, but its wide distribution, general niformity of character, and great amount, are clearly incompatible with the idea of its having been mainly of *local* derivation.

The above theory of the tripartite origin of the Boulder-clays will explain many facts which, at first sight, are calculated to puzzle the observer, and make him think that there is no constant order of succession in the drift-deposits of the north-western plain. The current-distributed subglacial clay could not, everywhere, have been equal in amount. It is indeed reasonable to suppose that in various *places*, and at various *times*, there would be a partial or even entire failure in the supply of this clay, so as to leave the sea nothing to deposit but loam, sand, or coarse local grit, which would often contain few or no erratics, as the currents which would bring the clay would likewise be the principal carriers of the floating coast-ice (part of which, however, would appear to have been blown in aberrant directions by wind).

In the lower clay, there is often a change in its character *upwards*, as if the supply of subglacial clay and erratic stones had been diminishing; in other words, it often becomes less stony, and more intercalated with loam or sand towards its junction with the *non-glacial* middle sand. This indeed might be expected on the supposition that the lower clay and middle sand were deposited during the same submergence.

The tripartite theory likewise explains the degeneracy of the clays *southward* from the source of supply; and *upward* on the hill-slopes where the clays gradually become more earthy and local in their character; for the progress of the submergence must have melted the ice upward, so as to limit its extent and consequent power of supplying subglacial clay.

D. Mackintosh.

COLOURING OF OOLITIC ROCKS.

Sir,—An excellent illustration of Professor Judd's remark on the colouration of the Oolites, quoted at p. 480, from "The Geology of England and Wales," may be now seen in a cutting on the Midland Railway to the north of Kettering. The bed is very low down in the Inferior Oolite, doubtless part of the Northampton Sands. It seems to be (I have only noticed it from the train, but I believe it identical with rock I have elsewhere examined) a soft sandstone, perhaps calcareous. Vertical joints divide its beds into blocks, so that there is a rough resemblance to courses of masonry. Sometimes these blocks are wholly brown; but in other cases the heart of a block is blue-grey, while the exterior for several inches is brown: so that it is evident that the former was the original colour, and that atmospheric water, as may be seen in so many other cases, has converted the pyrite (or, what is here more probable, the carbonate of iron, *vide* Judd, Geol. Rutland, p. 136) into limonite. The effect produced by this change along the planes of bedding and of jointing is very singular, something like masonry exceedingly coarsely pointed.

T. G. Bonney.

Erratum.—In the Rev. T. G. Bonney's article, Geol. Mag. Nov. 1877, p. 499, lines 8 and 14, *for* "Hungary," *read* "Bohemia."

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